

ENVIRONMENTAL MANAGEMENT SYSTEM MINA DE COBRE PANAMA

EROSION AND SEDIMENT CONTROL PLAN

June 2011

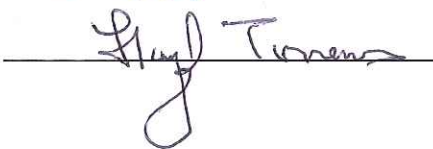
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  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	1

CLIENT: Minera Panama S.A. (MPSA)

PROJECT: Mina de Cobre Panama (MdCP)

		SIGNATURE	DATE
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ISSUE/REVISION INDEX

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Issue Codes: RC = Released for Construction, RD = Released for Design, RF = Released for Fabrication, RI = Released for Information, RP = Released for Purchase, RQ = Released for Quotation, RR = Released for Review and Comments.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	2

PREFACE

This document presents the Erosion and Sediment Control Plan (ESCP) that has been developed specifically for Minera Panama S.A., Mina de Cobre Panama Project. The document describes the environmental requirements, standards and procedures that shall be followed by Joint Venture Panama Inc. (JVP) personnel, its Contractors and Sub-contractors to minimize, reduce or eliminate potential environmental impacts from construction (including early works), start-up and pre-commissioning phases of project development.

The ESCP has been developed in accordance with the Social, Environmental and Community Affairs Standards of INMET Mining, and the Environmental and Health and Safety Policies and standards JVP, the EPCM contractor retained by Minera Panama for the Mina De Cobre Project.

The ESCP is one Environmental Management/ Action Plans of the included in the Environmental Management System (EMS) as follows:

Document Control Procedures

The ESCP is a dynamic document, which requires updates and revisions as project development activities progress, and new activities are undertaken. The document control procedures to be followed when revising or updating this ESCP or any of the Action Plans are provided in Section 5.4 of the Environmental Management System – Framework, Document 504832-0000-4EPA-0001.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	3

ENVIRONMENTAL MANAGEMENT SYSTEM

Document No.

504832-0000-4EPA-0001	Environmental Management System - Framework
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Health and Safety Focused Action Plans

504832-0000-68PA-0001	Health and Safety Management Plan
504832-0000-68PA-0002	Mina de Cobre Panama Project Site Health and Safety Plan
504832-0000-68PA-0003	Emergency Response and Crisis Management Plan
504832-0000-68PA-0004	Fleet Safety Management Plan
504832-0000-4EPA-0002	Spill Prevention and Control Plan
504832-0000-4EPA-0003	Hazardous Materials Management Plan

Environment Focused Action Plans

504832-0000-4EPA-0004	Environmental Education and Training Plan
504832-0000-4EPA-0005	Erosion and Sediment Control Plan
504832-0000-4EPA-0006	Vegetation Disposal Plan
504832-0000-4EPA-0007	Waste Management Plan
504832-0000-4EPA-0008	Water Management Plan
504832-0000-4EPA-0009	Construction Site Environmental Mitigation and Control Procedures
504832-0000-4EPA-0010	Air Quality and Noise Control Plan

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	4

504832-0000-4EPA-0011	Port Management Plan
504832-0000-4EPA-0020	Environmental Monitoring Plan
504832-0000-4EPA-0021	Environmental Recovery and Abandonment Plan
504832-0000-4EPA-0022	Archaeological Resources Management Plan
504832-0000-4EPA-0023	Biodiversity Action Plan
504832-0000-4EPA-0024	Reforestation Plan
504832-0000-4EPA-0025	Flora and Fauna Rescue and Relocation Plan
504832-0000-4EPA-0026	Aquatic Life Management Plan
504832-0000-4EPA-0027	Offsets Management Plan
Social and Community Affairs Focused Action Plans	
504832-0000-4EPA-0040	Social Development Action Plan
504832-0000-4EPA-0041	Resettlement Action Plan
504832-0000-4EPA-0042	Citizen Participation Plan

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
	Report No. 504832-0000-4EPA-0005		# PB	Date 2011- 06-24
				5

TABLE OF CONTENTS

1.0	INTRODUCTION.....	7
1.1	PURPOSE.....	7
1.2	SCOPE AND ORGANIZATION OF THE PLAN	8
1.3	PROJECT OVERVIEW	9
1.4	POLICIES AND REQUIREMENTS	18
2.0	PLAN IMPLEMENTATION	19
2.1	ROLES AND RESPONSIBILITIES.....	19
2.1.1	Minera Panama S.A. (MPSA).....	19
2.1.2	Joint Venture Panama Inc. (JVP)	22
2.1.3	Contractors.....	25
2.2	IMPLEMENTATION SCHEDULE.....	25
2.3	REPORTING AND AUDITING	25
2.3.1	Reporting.....	25
2.3.2	Remedial Actions	26
2.4	TRAINING	27
3.0	SITE CONDITIONS.....	28
3.1	INTRODUCTION.....	28
3.2	TOPOGRAPHY AND VEGETATION	28
3.3	PRECIPITATION	30
3.3.1	Mine site	30
3.3.2	Port.....	30
3.3.3	Transport /transmission corridor.....	30
3.4	SITE HYDROLOGY	30
3.4.1	Mine site	32
3.4.2	Port.....	32
3.4.3	Transport /transmission corridor.....	32
3.5	SOIL CHARACTERISTICS	32
3.6	SEDIMENT LOADING CHARACTERIZATION	33
3.6.1	Particle settling testing, yield estimation,.....	33
3.6.2	MPSA Erosion and Sediment Control field testing	33
3.7	ADJACENT NATURAL FEATURES.....	33
4.0	WATER MANAGEMENT	34
4.1	OVERALL WATER MANAGEMENT PRINCIPLES	34
4.2	HYDROLOGIC METHODOLOGY AND DESIGN STORMS	35
4.3	DESIGN CRITERIA FOR SEDIMENTATION CONTROL SYSTEMS	36
4.3.1	Diversion Channels	37
4.3.2	Drainage Ditches.....	37

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	6

4.3.3	Sedimentation Ponds	37
5.0	EROSION AND SEDIMENTATION CONTROL MEASURES	39
5.1	INTRODUCTION.....	39
5.1.1	Pre-construction Planning	39
5.1.2	Field Decisions For Implementing Best Managment Practices	40
5.2	EROSION AND SEDIMENT CONTROL MEASURES	41
5.2.1	Erosion Control Procedures	41
5.2.2	Sediment Control Procedures	43
5.3	PROCEDURE IMPLEMENTATION	44
5.3.1	Introduction.....	44
5.3.2	Schedule	44
5.3.3	Site Capture Phase	44
5.3.4	Construction Period.....	44
5.3.5	Operations Phase.....	45
6.0	MONITORING OF CONTROL MEASURES.....	46
6.1	PARAMETERS AND MEASURES OF SUCCESS.....	46
6.2	FREQUENCY.....	47
6.3	SAMPLING/MONITORING LOCATIONS.....	48
6.4	MAINTENANCE	48
6.5	DISPOSAL OF REMOVED SEDIMENTS.....	48
7.0	REFERENCES.....	49

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	7

1.0 INTRODUCTION

The Erosion and Sediment Control Plan (ESCP) is a key component of the Environmental Management System (EMS) which allows for the integration of engineering design and the environmental mitigation through implementation of environmental protection measures. By documentation of environmental protection measures for controlling erosion and sedimentation in a plan, performance can readily be measured, and the need for corrective measures can be determined.

In the best interest of its business, its employees, its shareholders, and the communities affected by the Mina De Cobre Panama Project, Minera Panama SA (MPSA) is committed to and will implement the Erosion and Sediment Control Plan through the development of its various project components.

1.1 Purpose

It is MPSA's intent that the Project is carried out in an environmentally responsible manner with implementation of environmental mitigation in compliance with local regulations and international standards for mining projects. This report constitutes the Erosion and Sediment Control Plan (ESCP) for the Mina De Cobre Project to be implemented during the life of Project. The objective of the ESCP is the control of potential soil erosion and sedimentation, as a result of Project activities, thereby ensuring environmental protection of land, water, air and aquatic resources. In preparing the ESCP, careful consideration has been given to the proposed land disturbing activities and site-specific physical characteristics of the property such as soils, drainage, expected runoff from precipitation and sensitivity of adjacent natural features.

This plan has been developed to address construction issues related to erosion and sediment control expected to be encountered during the implementation of the Project, especially as it relates to facilities such as temporary access roads and construction areas to be prepared before construction of permanent sediment control structures (sedimentation dams, tailings management facility) are completed. The practices and strategies laid out are intended to provide guidance to Project staff and contractors in these temporary works, as well as initial works related to the permanent project controls for sedimentation which will be outlined in the Water Management Plan.

The ESCP will be a 'Living Document' that will be updated as the project move basic engineering, detailed design, construction and operations. It will be reviewed through each stage and will be updated on an as-required basis.

A variety of erosion and sedimentation control, prevention and mitigation measures are to be implemented during the construction, operations and closure phases of the Project to minimize potential environmental impacts. In the development of the ESCP for the Project, the following guiding principles were adopted to minimize impacts to soil, air, water and aquatic life:

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	8

- Limit slope length and gradient for disturbed areas;
- Design and maintain gentle slopes for all stockpiles and waste rock dumps;
- Clearly delineate areas designated for earth disturbing/grading activities and ensure appropriate erosion and sediment control measures are implemented prior to commencement of construction;
- Where vegetation exists, maintain vegetative cover for as long as possible during the construction phase and limit grubbing activities for site facilities, where feasible;
- Control and direct sediment laden runoff from key mine components (i.e., waste rock dumps, TMF dam face, open pit) through collection ditches to sedimentation ponds to reduce that amount of suspended solids prior to discharge to the environment;
- Ensure culverts have appropriate inlet and outlet erosion protection at all drainage crossing points of the roads in the Project area;
- Progressively stabilize disturbed areas during construction and operations, such as material stockpiles, TMF dam face and waste rock dump slopes, with vegetative cover or other protection measures (i.e., aggregate, plastic liner, etc.) to limit exposure to erosive forces (i.e., wind, water); and
- Implement an environmental inspection program to verify the implementation and appropriateness of environmental protection and mitigation measures and to ensure that measures are adequately monitored, maintained and, where necessary, that corrective actions have been taken to address a non-compliance issue.

1.2 Scope and Organization of the Plan

This plan is an environmental “execution plan” for use in the field during the construction phase of the Mina de Cobre Panama Project and includes applicable and necessary information to carry out construction activities in such a way that its environmental impacts are avoided, minimized or mitigated. It has been developed in accordance with the Project Environmental Design Criteria, and in conjunction with other plans, under the Environmental Management System, enable the Project to meet IFC, Panamanian and other applicable standards (presented in Section 1.4). It is a dynamic document and is subject to modifications as the Project advances.

The plan should be implemented in all the project activities of the Mine during construction phase. The construction of the Power plant is not under JVP’ supervision therefore is not subject to this plan. The Community affairs is outside of the scope of this plan as well as Health and Safety aspects which are considered in the Health and Safety Management Plan and the Project Site Health and Safety Plan, components of the Environmental Management System of the project.

The present plan includes the following sections:

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	9

The **Preface** describes the ESCP in the context of the overall EMS and the revision and document control procedures.

Section 1 (this subsection) provides an **overview of the Project and purpose of the ESCP**.

Section 2 identifies the **roles and responsibilities** for implementation and overall management of the ESCP.

Section 3 provides background **on existing conditions and features** relevant to erosion and sediment control planning and design.

Section 4 provides a summary of the **site water management analysis and design criteria** for key erosion and sediment control measures in the ESCP.

Section 5 provides a summary of general **erosion and sediment control measures and techniques** for implementation in the ESCP and their selected application in the site capture, construction, and operations phases of the Project.

Section 6 describes the **site monitoring program** for erosion and sediment control measures.

1.3 Project Overview

The Petaquilla Concession covers an area of 130 square kilometres (km²) and is located in the Donoso District, Colón Province in north-central Panamá.

The Project mine and concentrator facilities will be located about 25 kilometres (km) south of Punta Rincón and 12 km west of Coclesito Ore mined from open pits will be processed by crushing, grinding, flotation recovery and concentrate dewatering. The Project design is based on an initial ore feed rate of 150,000 tonnes per day to the grinding plant, increasing to 225,000 tonnes per day after year ten of operations.

Copper concentrate will be delivered by slurry pipeline from the concentrator to the filter plant and port at Punta Rincón. After pressure filtration, the dewatered concentrate will be loaded on to bulk concentrate vessels for delivery to international customers. The port and concentrator sites will be linked by a road, buried pipelines for concentrate slurry, return filtrate, diesel fuel, and an overland power transmission line. A coal-fired power generation plant will be built at the port site by an independent power producer.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	10

The scope of the Project has been defined for 30 years of operation; within this scope, the primary physical facilities include:

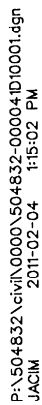
- Three open pits (at the Botija, Valle Grande and Colina deposits) which will be progressively developed and then backfilled or filled with water and left as a lake over the life of the mine;
- Ore crushing, conveying and stockpile facilities, consisting of two gyratory crushers, belt conveyors and a pad for crushed ore stockpiling;
- The concentrator, which includes:
 - o A grinding plant with two semi-autogenous (SAG) mills and four ball mills
 - o A flotation plant with large tanks for the separation of copper concentrate from its host rock (referred to as “tailings” after the separation and extraction); gold and silver values will be recovered in the copper concentrate.
 - o Concentrate thickening to prepare the concentrate to the proper consistency for transport by pipeline, and tankage to provide surge capacity; A flotation circuit to separate molybdenum from copper concentrate, with dewatering, filtration and bagging for shipment;
- A tailings management facility (TMF), which will receive the processed material in slurry from the concentrator after extraction of metal values;
- Waste rock storage facilities for deposition of mine waste during the mining operation (for non-economic material segregated in the mine from ore);
- Low-grade ore stockpiles;
- Surface water ponds for the supply of cooling water, potable water and process water make-up;
- Ancillary facilities in the vicinity of the mine and concentrator, including a truck and mobile equipment maintenance shop, offices, and an explosives preparation and storage facility;
- Water diversion and sediment control structures;
- Facilities and systems for environmental monitoring and management of effluents in compliance with project commitments;
- Eastern access road, connecting the existing road from Coclesito to the Mine entrance.
- Llano Grande Road upgrade;

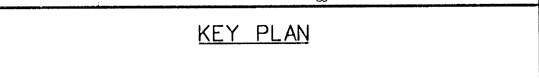
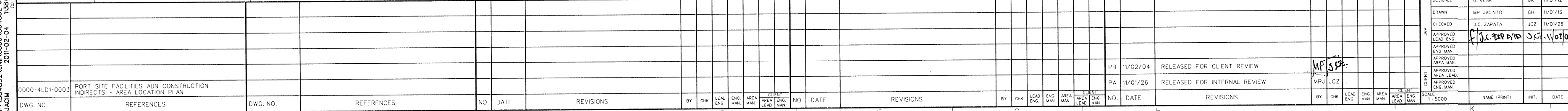
  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	11

- Power transmission lines from Llano Grande sub-station to the mine plant site, and from the project's power generation plant at Punta Rincón and to the mine plant site.
- Camp facilities for personnel during construction and for operations;
- Landfill for deposit of solid domestic waste from the camps situated at both the Mine Site TMF and Port site during construction, and at the Mine Site TMF during mine operations;
- 2 Incinerators, one at the mine site and one at the Punta Rincon port site;
- The Punta Rincón site, which includes:
 - o Copper concentrate filter plant
 - o Copper concentrate storage building
 - o Port with ship loading facilities for concentrate carriers and for the receiving of fuel and operating supplies
 - o Temporary facilities for the receiving of equipment and supplies during construction
 - o Camp facilities for personnel during construction and operations
 - o Coal-fired power station for the generation of electricity, together with its coal handling and storage facilities, ash disposal and water systems
- Coast road, connecting the concession with Punta Rincón, with the following buried under the right-of-way of the coast road:
 - o a concentrate pipeline to deliver copper concentrate product to the filter plant at Punta Rincón
 - o a fuel line
 - o a return line for the effluent from the dewatering to send fly ash from the power plant to the tailings impoundment.

The key project components are shown on the following drawings:

<u>Description</u>	<u>Drawing Number</u>
Overall Site Plan	504832-0000-41D1-0001
Mine Site Plan	504832-1000-41D1-0001
Port - Site Plan	504832-6000-41D1-0001
TMF - Overall Plan	504832-2350-41D1-0001
Eastern Access Road - Overall Plan and Profile	504832-3120-41D1-0001
Port to Plant Access Road – Overall Plan and Profile	504832-3110-41D1-0003





Minera Panamá

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  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	15

Insert TMF - Overall Plan

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- GENERAL NOTES:**
1. ALL ELEVATIONS, DIMENSIONS AND COORDINATES ARE IN METRES UNLESS NOTED OTHERWISE.
 2. CONTOURS ARE FROM AERIAL MAPPING SUPPLIED TO MINERA PETAQUILLA S.A. - MPSA - BY AIRBORNE SOLUTIONS INC. (JUNE 2008) BASED ON WGS 1984 DATUM AND UTM ZONE 17-N MAPPING PLANE.
 3. IN ADDITION TO THE AERIAL MAPPING PROVIDED PER NOTE 2, MCELHANNAY CONSULTING SERVICES LTD. ALSO PROVIDED MPSA NINE CONTROL POINTS PER REPORT ON THE CONTROL SURVEY DATED JUNE 4, 2008.

LEGEND:

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PROYECTO MINA DE COBRE PANAMÁ

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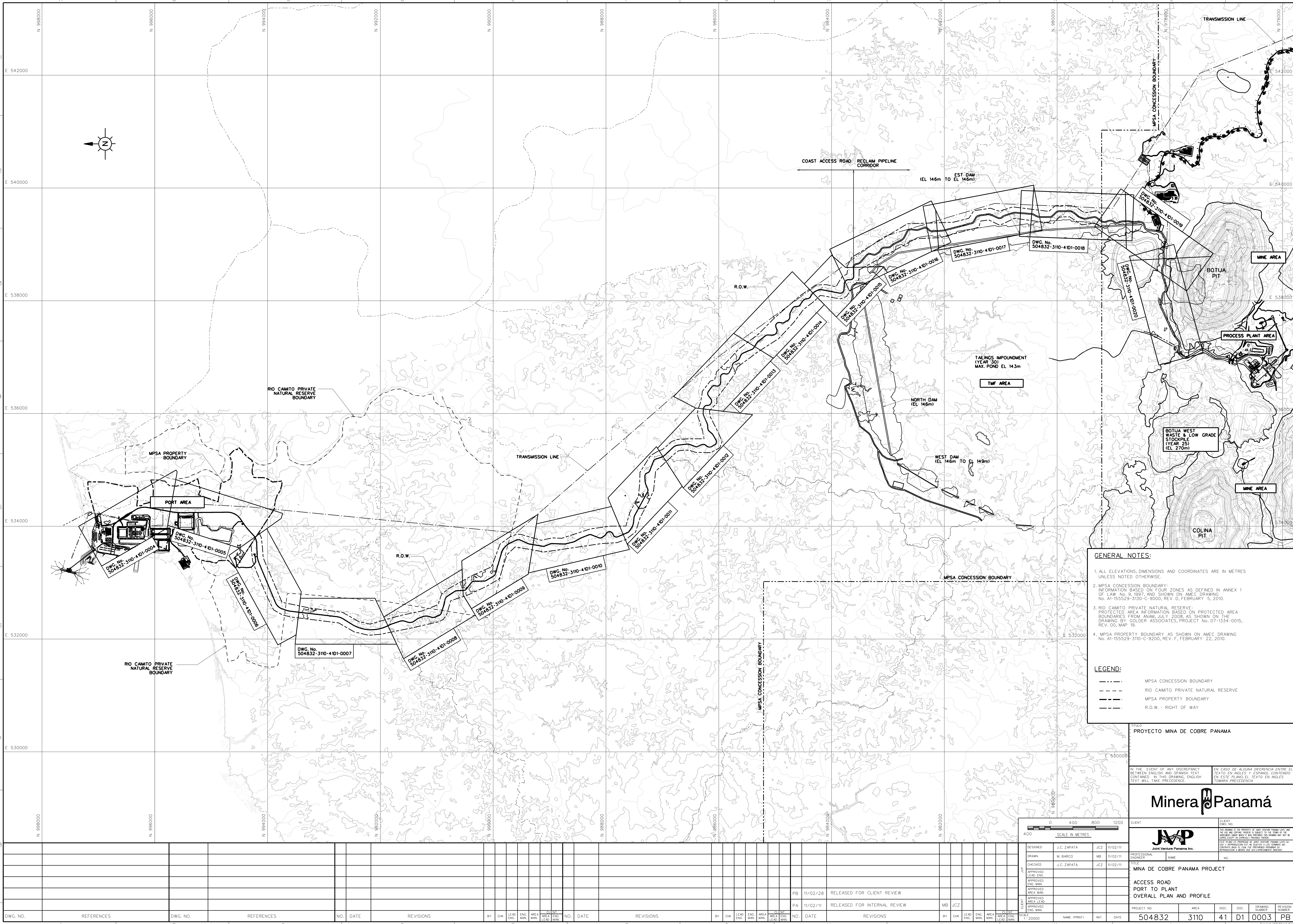
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PROFESSIONAL ENGINEER
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	CHECKED	W. PALMER						WP	11/04/07			
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  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	18

1.4 Policies and Requirements

A full review of the policies and requirements governing the Project is provided in the Environmental Management System (Plan No. 504832-0000-4EER-1000) Section 2. In regard to erosion and sediment control the project is responsible for meeting the criteria for Total Suspended Solids (TSS) in mine effluent for:

- IFC Environmental, Health and Safety Guidelines: Mining (December 2007) – 50 mg/L
- Republic of Panama – Resolution 351 (26-05-2000) which approves Technical Guideline DGNIT-COPANIT 35-2000 -Discharge of Liquid Effluents into surface water and groundwater – 35 mg/L (under normal operating conditions)

The ESIA baseline study on water quality found that as a result of the highly erodible saprolitic overburden, combined with high annual rainfall, and frequent intensive events, periodically and naturally elevated TSS concentrations occur within the natural drainage in the project area. TSS concentrations in streams can range from 200 mg/L up to a maximum measured of 1,610 mg/L for periods of heavy rains. Given these results further studies are being undertaken by the project team to assess sediment yields that may be associated with the project. In the interim the project design criteria has been set at 50 mg/L for TSS 95% of the time (in accordance with IFC EHS Guidelines) with an operational target of 35 mg/L under normal operating conditions.

In addition to details provided in this plan erosion and sediment controls shall have regard for:

- Ministerio de Obras Publicas - Manual de Especificaciones Técnicas de la Institución. Cap 30 – Control de Erosion.
- MPSA procedure– Control de la Erosion – PRO-100215

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	19

2.0 PLAN IMPLEMENTATION

This section of the ESCP will present the roles and responsibilities for all staff in implementing the plan, schedule for implementation, as well as reporting structure and training for project staff.

2.1 Roles and Responsibilities

2.1.1 Minera Panama S.A. (MPSA)

MPSA employees and contractors will have overall responsibility for implementing the EMS through the different phases of the Project, from construction through operations to closure/post-closure. MPSA is responsible for ensuring that all mitigation activities aimed at reducing the adverse impacts of the Project to acceptable levels. In addition, MPSA is responsible for ensuring the implementation of the monitoring programs required to verify that mitigation measures are achieving their targets. Figure 2-1 provides an environmental organizational chart under which the EMS will be implemented.

MPSA Environmental Team

MPSA Environmental Team consists of personnel at both the Project corporate and in country level. It has an overall responsibility of implementing the ESCP through the different phases of the project.

Corporate Environmental Director

The Corporate Environmental Director will be responsible for ensuring the environmental component of the Mina de Cobre Panama Project is implemented in accordance with INMET corporate policy.

MPSA Environment Director

To be located in the MPSA office in Panama City, the Environment Director will be primarily responsible for ensuring the construction of the project is conducted in accordance with all applicable Panamanian environmental legislation, ESIA and the environmental permit, Project Environmental Commitments and SECA and JVP policies/standards. He is also responsible for government approvals and compliance reporting as well as government, employee and public relations. Additional responsibilities will include provide direction to the MPSA site Environmental managers and advising in recruiting, hiring, training, transportation and housing of Project personnel. **The MPSA Environment Director reports directly to the Corporate Environmental Director.**

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	20

MPSA Environment Superintendents

The Environment Superintendents will be responsible for coordination of their respective area and work front and ensuring that all construction activities and developments are conducted in accordance with the Project commitments as specified in the ESIA, Environmental Permit and all additional permits/approvals and in accordance with the EMS and Action Plans including this ESCP. They will provide guidance and supervision to the environmental supervisors and monitors of each work front of the construction packages. The MPSA and JVP Environmental Superintendents are expected to coordinate the Project environmental meetings as needed. The Superintendents will report to the Environmental Management System Manager.

Reforestation Superintendent

The Reforestation Superintendent will be responsible for the reforestation aspects during construction, operations and closure phase. He will be supported by a Reforestation Supervisor to do the day-to day activities. He will make sure that the Reforestation Plan is being implemented according to MPSA commitments and standards. The Reforestation Superintendent will report to the Biodiversity and Reforestation Manager.

Environmental Monitoring Superintendent

The Environmental Monitoring Superintendent will be responsible for monitoring the day-to-day activities on-site to ensure that they are conducted in an environmentally compliant manner, and in accordance with the EMS and Action Plans. The Environment Monitoring Superintendent will report directly to the MPSA Environment Director.

Environmental Compliance Superintendent

The Environmental Compliance Superintendent will be responsible for maintaining, monitoring, and updating all Project environmental regulatory requirements; implementation (in conjunction with the Environmental Management System Manager) and compliance with Mina de Cobre Panama Project environmental standards and training; and all environmental-related records and reporting requirements. The Environmental Compliance Superintendent will report directly to MPSA Environment Director.

Environmental Supervisors and Coordinators

The environmental Supervisors and Coordinators will assist each of the Superintendents to accomplish the Environmental tasks related to their specific area or discipline assigned.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	21

<Placeholder for Figure 2-1 MPSA Environmental Management Team Organizational Chart>

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	22

2.1.2 Joint Venture Panama Inc. (JVP)

Joint Venture Panama Inc. (JVP) has been retained by MPSA to serve as the Engineering, Procurement and Construction Management (EPCM) contractor for the Project. JVP will provide engineering and procurement services from its office in Toronto, Ontario, Canada as well as the required on-site construction management services for the Project.

The following identifies the roles, responsibilities, and reporting structure of key JVP personnel committed to the Construction Management Team for execution of the Mina De Cobre Project. An organization chart of key JVP staff assigned to the Project is presented in Figure 2-2.

The **Project Director** will be responsible to ensure detailed design, engineering, procurement and construction services, agreed with the Owner, are fully implemented in accordance with Contract and industry practices. Procedures and work instructions issued by the Project Director are to be followed by the JVP Project Team in the day-to-day construction management and administration of the Project.

The **Construction Director** reports to the Project Director and will be the senior JVP representative on-site. In addition to the management and supervision of the construction management team assigned to the Project, the Construction Manager is responsible for the management and coordination of all project construction activities. The Construction Manager, in concert with MPSA's representative, will also be responsible for liaison with government regulators as required.

The Construction Director will be responsible to ensure construction permits are in place for each construction activity. MPSA is responsible for coordinating and obtaining all project permits. The Construction Manager is also to advise on responsible management methods and procedures, and assist in the implementation of plans and procedures identified in the ESCP and other sub-plans in the EMS for the Project.

The Construction Director is ultimately responsible for the successful implementation of the ESCP prior to the transfer of operations to MPSA.

The **Environmental Manager** will be responsible for the overall environmental aspects of the Mina de Cobre Panama Project. He will advise the Site Environmental Manager in accordance with the EMS. The Environmental Manager will be responsible for any updates or amendments to the ESCP and for ensuring that mitigation measures suit specific field conditions, as the construction proceeds.

The **Site Environmental Manager** reports to the Construction Director with regards to issues associated with construction and scheduling, and to the Environmental Manager for the Project with regards to issues related to the environmental compliance of the project. Where conflict arises between the two reporting issues, the advice of the

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	23

Project Director will be sought. The key responsibility of the Site Environmental Manager will be to monitor and document the day-to-day activities of contractors to ensure they are in compliance with environmental permits and the applicable regulatory framework for the Project, as well as all environmental commitments made by MPSA in the *Environmental and Social Impact Assessment* (ESIA) and the EMS, including the more specifically the subject ESCP. With the assistance of other environmental staff identified below, the Site Environmental Manager will be responsible for ensuring that erosion and sedimentation control mitigation measures are properly implemented, maintained and are functioning as designed, with particular care given, prior to and following rainfall events in order to minimize potential environmental impacts. The Site Environmental Manager will maintain daily records and provide written summary reports to the Construction Director and Environmental Manager on a regular basis. He is to investigate and follow-up on all non-compliance incidents related to erosion and sedimentation controls and other environmental management issues and to advise on corrective measures.

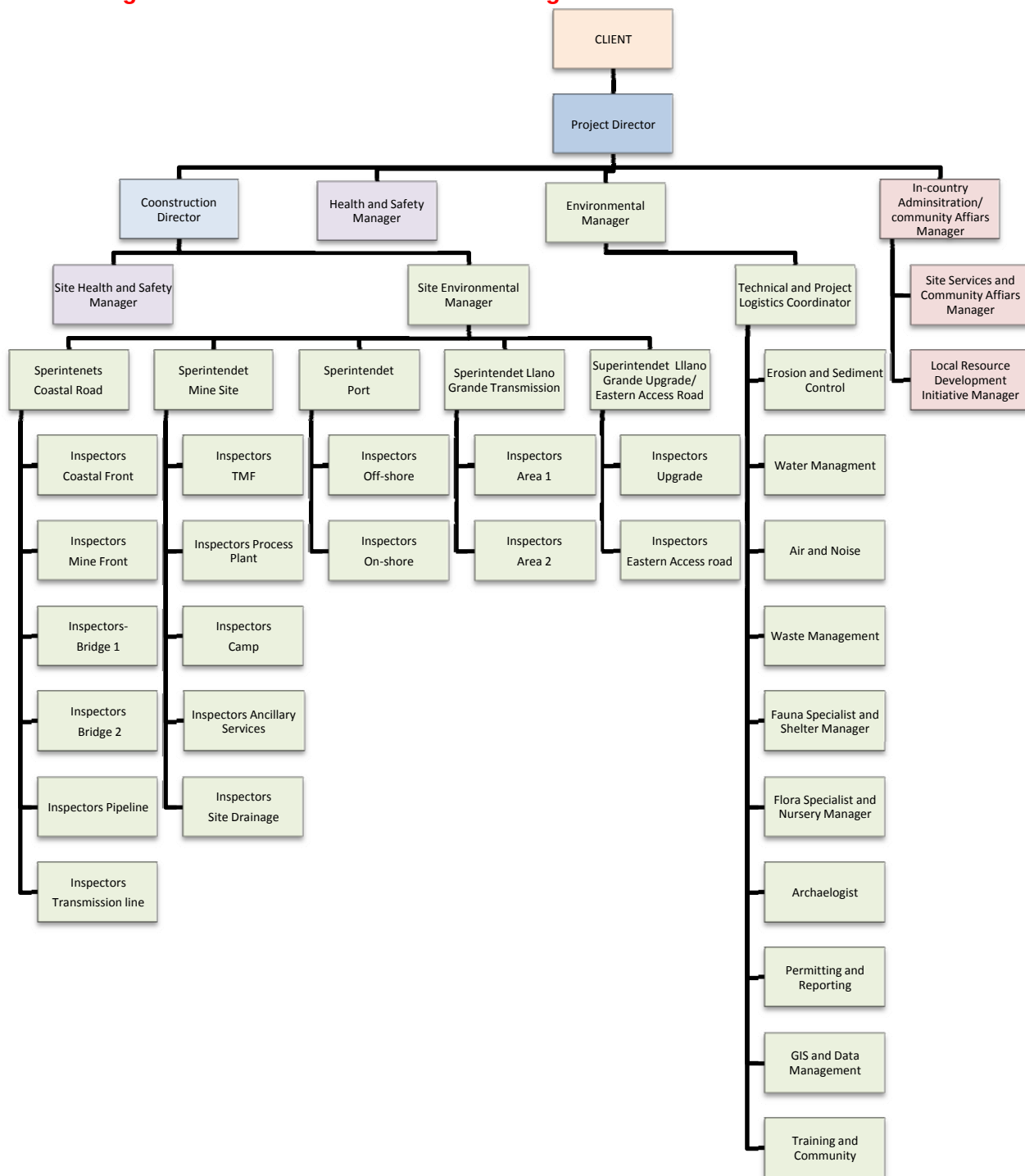
The **Area Environmental Superintendents** report to the Site Environmental Manager and are responsible for ensuring proper implementation of the day-to-day activities associated with the ESCP for all works within their area of responsibility (e.g. Mine Site, Port Site, etc.). They will be responsible for compiling area weekly reports for delivery to the Site Environmental Manager and will ensure that Job Environmental Analysis (JEA) documentation has been completed for all necessary works in their area of responsibility. They will be responsible for reviewing and approving all JEA's for their area of responsibility, and will follow the day to day activities closely as well as upcoming works to anticipate the need for additional control measures or strategies. They will also be responsible for coordinating the Environmental Inspectors in their area and assembling daily and weekly activity logs for Project reporting.

The **Environmental Inspectors** report to the Area Environmental Superintendents and are responsible for following the day to day activities of the Contractors on-site to ensure that the activities are conducted in accordance with the JEA, as completed by the Contractor, and the ESCP. They will liase directly with contractors and construction crew. As it relates to erosion and sediment control they will also be responsible for monitoring the effectiveness of measures put in place and will provide daily and weekly reporting information to the Environmental Superintendent.

The **Enviromental Technical Specialist for Erosion Control** will report to the Environmental Manager, either directly or via the Technical and Project Logistics Coordinator. He will be responsible for providing technical advice to Environmental Superintendants and Environmental Inspectors on issues related to the ESCP across all project areas. This will include review of JEA's, shop drawings, as well as issued for construction drawings as needed. He will also be responsible for assessing the effectiveness of the monitoring program on a Project-wide scale, and providing input to Project reporting in this regard.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	#	Date			
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	24	

Figure 2-2 JVP Environmental Team Organization for Construction



  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	25

2.1.3 Contractors

Construction Contractors are required to adhere to the Project EMS and more specifically the ESCP. Each Contractor shall appoint an Environmental Representative to attend weekly meetings, become acquainted with all permits, approvals and regulatory provisions in force, and be the principle contact with the JVP Environmental Inspector.

Contractors are responsible for the implementation, prior to the initiation of all work activities, and maintenance of temporary erosion and sediment control measures throughout the life of their contract, as required to address specific work activities and the existing environmental conditions for their area(s) of activity.

The erosion and sediment control measures to be implemented by the Contractor are subject to the approval of the JVP Environmental Inspector, in consultation with the JVP Construction Representative, through the JEA process.

2.2 Implementation Schedule

Implementation of the erosion and sediment control plan will form a crucial component of the Project's environmental program from the start of the early works and site capture phases. Many of the practices and procedures outlined in this plan are designed for use during construction, when conditions are temporary, and basin control has not been established.

As progressive areas are opened up throughout the site capture and construction phases proper erosion and sediment control will continue to play a critical role for meeting Project commitments. Once the establishment of ultimate site drainage is achieved and during the operations phase this plan still provides guidance for maintenance of existing control measures and a set of practices that may be used to address problems which arise throughout the lifetime of the mine.

2.3 Reporting and Auditing

General environmental reporting requirements associated with the implementation of the EMS is provided in the Environmental Management System document (No. 504832-0000-4EPA-0001). This section addresses only reporting requirements associated with the ESCP.

2.3.1 Reporting

Environmental Inspectors will be required to report any identified areas of erosion or sedimentation concern following regular inspections and after periods of heavy rain or major storm events, so that remedial action can be taken as soon as possible. An

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	26

environmental monitoring log/diary for each area will be maintained by the Environmental Superintendents based on input provided by the Environmental Inspectors. An environmental inspection form will provide information with respect to installation, maintenance and removal of erosion and sediment control measures, along with identification of any deficiencies and record of actions taken to correct problems. A copy of the inspection form is provided in Appendix A.

Site observations, inspection reports, and recommended actions will be included in a weekly report to the Construction Manager and Site Environmental Manager. Results in field water and soil sampling and supporting analytical testing will be provided to the Site Environmental Manager for inclusion in regular reporting documentation. Monitoring results of erosion and sedimentation control measures may be included in an annual Environmental Monitoring Report addressing erosion and sediment control issues. This information will be incorporated into the MPSA annual monitoring report for distribution to appropriate central and local government agencies.

2.3.2 Remedial Actions

All Project Staff (MPSA, JVP, Contractors) are expected to identify environmental issues, including erosion and sediment issues, to the best of their abilities. Contact information for JVP Environment Staff will be provided to all staff; however, each contractor is expected to have their own reporting structure to their Environmental Representative. Once an issue related to erosion and sediment control is identified JVP Environment should be notified immediately. JVP's Environmental Staff shall have the authority to require the Contractor to take corrective action and, if necessary, to interrupt any work that is:

- Considered NOT to be in compliance with this document or any of the Project's permits/approvals; and
- Deemed to be in contravention of regulatory requirements (e.g., environmental permits) and, as such, represents an environmental risk or concern.

In the event of a "Stop Work Order", the Contractor shall not resume its regular activities until corrective action is taken to resolve the cause of the work stoppage. JVP's Environmental Representative shall approve the re-initiation of stopped work.

A Non-Compliance Report will be completed by JVP's Environmental Representative, with the assistance of the Contractor's Environmental Representative and distributed to Project Team members. The Non-Compliance Report shall indicate the activity that resulted in non-compliance and the remedial action that the Contractor shall put in place. A copy of the Non-Compliance Report can be found in Appendix B. Where warranted, depending on the severity of the environmental impact, an Environmental Incident Report will be completed. A copy of the Environmental Incident Report can be found in Appendix C.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	27

2.3.3 Auditing

The JVP Environmental Department will conduct audits of construction, operations and closure/post-closure activities to ensure Project activities conform to ESIA commitments, IFC PS, applicable Panamanian legislation, permit requirements, and MPSA's SECA Standards. MPSA compliance audits will be performed on a rotating annual basis to independently verify compliance with applicable legislation, company policy and mining industry good management practices.

2.4 Training

Environmental Orientation and Training is a mandatory requirement for all Project personnel (MPSA, JVP, Contractors, and Sub-contractors) prior to commencing any work activities at the Mine Site.

It is important that all personnel whose work could potentially impact the environment receive appropriate environmental training. Additional environmental training required for implementing protection procedures, and/or completion of required forms (e.g., JEA), will be provided by the respective Contractor and/or JVP, based on an individual's specific work activities and the degree of interaction (i.e., direct or indirect) with the environment therefore determining an individual's potential to impact the environment.

Environmental orientation will be delivered by the JVP Environmental Team as a component of the overall Site Orientation Program. The objective is to identify and provide appropriate training on environmental issues /sensitivities to all personnel on the Project to ensure they are aware of the importance of conforming with the Project's Environmental and Social Policies, and the Construction Environmental Mitigation and Control Plan based on:

- Potential effects and consequences of their work activities;
- Potential environmental benefits of improved environmental performance; and
- Roles and responsibilities of each Project personnel in achieving environmental performance.

The environmental awareness of all Project personnel will assist the Project in achieving its environmental goals and objectives. An outline of the environmental awareness and educational training is provided in the Environmental Education Plan (504832-0000-4EPA-0004).

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	28

3.0 SITE CONDITIONS

3.1 Introduction

Soil erosion is caused by the impact of rain or wind on the soil surface. Sedimentation is the process that deposits soils either on the ground or in bodies of water or watercourses. Although erosion is a natural process in the environment, land-disturbing activities, such as clearing, grading, excavation and soil movement can significantly increase erosion and sedimentation rates.

Potential Impacts of erosion and sedimentation to the environment from land-disturbing activities include:

- Damage to vegetation and wildlife habitat;
- Degradation of water quality in watercourse; and
- Destruction and/or degradation of aquatic habitat and impacts on aquatic life.

The extent of potential erosion from land-disturbing activities, associated with the Project, is influenced by:

- Topography (slope length, steepness drainage);
- Vegetative cover (type and condition);
- Soil characteristics (structure, texture, permeability and organic matter content); and
- Local climate/rainfall (frequency, intensity and duration).

The following sections provide a brief description of the existing conditions at the Project area, which were considered in assessing site erosion potential and determining the required mitigation measures to minimize erosion and sedimentation effects.

3.2 Topography and Vegetation

In general, the topography of the Project area is characterized by rolling hills with slopes varying from 15-45%. In some portions of the Project area terrain is more rugged and slopes can exceed 70%. Approximately 88 percent of the Project footprint is covered with intact, primary, undeveloped forest, classified mostly as tropical lowland evergreen broadleaf forest. Less than 1 percent of the footprint is covered with mature secondary forest and 5 percent is covered with secondary forest which is not yet mature. Secondary forest has been disturbed by some type of human impact. Approximately 7 percent of the Project footprint has been cleared for habitations, agriculture, ranching and infrastructure such as trails or roads.

Elevations in the Project area range from 0 m to 400 m above mean sea level (ASL) moving from the Port to the Mine Site. Figure 3-1 provides the existing topography of the Project area.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	29

Holder Page for Topography Map

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	30

3.3 Precipitation

Climate and meteorological information available from historical data at regional weather stations indicate rainfall tends to increase from inland locations (e.g., the mine site) to the Caribbean coast (e.g., the port site). February and March are typically the drier months with an average of about 175 to 200 mm of rainfall. The rest of the months are characterized by steady moderate to high rainfall, with the largest amounts generally occurring in November and December (550 to 700 mm). Significant rainfall events can and do occur throughout the year, and there is a high degree of variability in monthly and interannual precipitation.

3.3.1 Mine site

Mean annual rainfall at the mine site is estimated to be about 4,500 millimetres (mm) based on long-term records at the San Lucas and Boca de Toabré regional stations, and based on a comparison between the available short-term records.

3.3.2 Port

Mean annual rainfall at the port site is estimated to be about 5,000 mm based on long-term records at the Cocle de Norte regional station, although short-term records for the port site indicate that rainfall at the Caimito River may be higher. .

3.3.3 Transport /transmission corridor

There is no annual estimate of rainfall for the transport/transmission corridor. However, based on trends seen in regional stations (decreasing rainfall moving inland) it can be reasonably inferred to be somewhere between 4,500 and 5,000 mm annually.

3.4 Site Hydrology

The project site is located at the topographical divide of three basins which may be impacted by runoff from project infrastructure (mine, linear developments, port) and flow either directly or ultimately into the Caribbean Sea:

- Petaquilla River;
- Caimito River; and
- San Juan River (tributary to the Cocle del Norte River).

Figure 3.2 presents the Hydrology Map of the project area.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	31

Holder page for Hydrology Map

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	32

3.4.1 Mine site

Works associated with the development and construction of the mine site (pit development, stockpiles, TMF, plant site) will affect all three major systems or their tributaries.

The Petaquilla River basin drains northwest from the west side of the mine site to the Caribbean coast. Petaquilla River is the main watercourse within the basin, with no substantial tributaries along its length. Pits and waste rock storage facilities will be located within this basin. The plant site, TMF and waste rock storage facility will be located in the upper reaches of the Uvero River (a tributary of the Caimito River) which drains the project area to the north. The Botija River (a tributary of the San Juan River) drains the project area to the east and its basin is intended for both pit and a waste rock storage facility.

3.4.2 Port

A small portion of the power plant and port footprint would be located within the lower Caimito River basin, on the west side of the Caimito River estuary.

3.4.3 Transport /transmission corridor

The corridor for the transportation/transmission infrastructure (port to plant road, pipelines, and transmission lines) will cross the Uvero River and Rinconcito River, both tributaries of the Caimito River.

3.5 Soil Characteristics

Soils in the Project region are predominantly ultisols: highly weathered, tropical soils that are generally low in nutrients. The soil layer, which covers the rocks, ranges in thickness from less than a few metres to over 30 m. The high rainfall in the region promotes weathering and mineral leaching. The warm soil temperatures and high moisture conditions help organic matter such as leaves to degrade rapidly. As a result topsoil and subsoil reclamation suitability are rated as marginal to moderate due to soil acidity and soil fertility.

Surface soil erosion potential is dependent on slope gradient but in general is considered to be high throughout much of the Project area. The organic and saprolite materials are the soils that would be most susceptible to erosion forces and mobilization of sediment particles. The saprolite material is a fine grain silt and clay material with a D₅₀ typically ranging from 0.1 to 0.01 mm.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	33

3.6 Sediment Loading Characterization

3.6.1 Particle settling testing, yield estimation,

3.6.2 MPSA Erosion and Sediment Control field testing

Input required from Water Management Strategy work currently in progress

3.7 Adjacent Natural Features

The Mina de Cobre property lies within the Mesoamerican Biological Corridor of the Panamanian Atlantic (MBCPA), which is not protected but is recognized by Panamá as a means to interconnect protected areas in adjacent countries, promote investment in conservation and improve the quality of life of residents in the region. Protected areas near the Project include: the General Omar Torrijos National Park located approximately 10 km south of the Project, and the Santa Fé National Park approximately 14 km southwest of the project. Both parks are managed and overseen by *Autoridad Nacional del Ambiente* (ANAM). Two other reserves, La Yeguada Forest Reserve, and Los Pozos de Calobre Natural Monument are located within 50 km of the Project area.

A reserve known as Reserva Natural Privada “Rio Caimito” was created by an ANAM resolution on November 23, 1998 (ANAM 1998). This is a private reserve, which has been recognized formally, but is not a protected area under the national regulatory framework. The area is owned by a variety of individuals, who have voluntarily agreed to the private reserve. Land owned by MPSA is not part of the reserve, and therefore is not subject to legal protection.

The Project area and surrounding moist evergreen broadleaf tropical forests shelter some of the greatest biodiversity in the region. In general, the area supports a high diversity of plants, mammals, birds, reptiles and amphibian. There are also known sensitive and vulnerable flora and fauna species that are present in or near the Project area, which are listed with the International Union for the Conservation of Nature (IUCN) and IUCN Red List of Threatened Species. As such, the diversity of the species of flora and fauna and the consequent structuring and complexity of the habitats are considered sensitive and require protection from potential erosion and sedimentation effects, resulting from mining activities, particularly during the construction phase.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	34

4.0 WATER MANAGEMENT

This section of the ESCP presents a brief overview of the Water Management Plan for the Project (504832-0000-4EPA-0007). This Plan should be read in conjunction with the Water Management Plan which deals primarily with the major design elements and major infrastructure (diversion channels, sedimentation and runoff collection ponds, etc.) proposed to manage erosion and sediment at the Project sites upon their completion. While this is not an exhaustive review of these Project elements they are reviewed here for context in the overall erosion and sediment control scheme.

4.1 Overall Water Management Principles

For this Project, a distinction is made between contact and non-contact waters. Contact waters include runoff and seepage from areas where water has potentially been impacted by contact with process waters, ore stockpiles, waste rock dumps, landfill waste or leachate, pit dewatering, etc. These contact waters may exhibit depressed pH and elevated heavy metal concentrations as a result of acid rock drainage/metal leaching (ARD/ML) and hence may require more extensive monitoring, management and treatment prior to their release to the environment. Non-contact waters have not been subject to contact with process waters, ore, waste rock or other Project-related activities. These non-contact waters are considered to be comparable to the background quality of natural drainage in the area and as a result these waters are diverted around the sites to minimize water management and potential treatment requirements.

The water management approach is guided by several principles as follows:

- Minimize contact water by minimizing the exposure of disturbed areas to flowing water and by diverting upstream water around construction activities and site facilities;
- Preventing erosion at the source is preferred to dealing with it after it has occurred. Sediment control practices should attempt to trap sediment close to the source and prevent sediment movement from the site;
- Non-contact water that is diverted around the construction areas and/or does not come into contact with construction activities will be discharged back into its respective watersheds wherever practical;

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	35

- Manage contact and non-contact waters separately to the extent possible;
- To limit silting of water bodies downstream from all construction activities, storm water management control facilities will be put in place, as appropriate to the location and activity, prior to any bulk earthwork activities including: clearing, grubbing and pre-stripping activities;
- Progressive reclamation and rehabilitation of mine sites and waste rock storage facilities throughout the life of the mine will be conducted;
- Some construction activities may need to be halted during intense storms to avoid excessive siltation and mobilization of suspended solids;
- Sedimentation ponds constitute the final engineered structures for the control of surface runoff and sediment loading prior to the release of water to the environment;
- Monitoring of the quality of collected water in the TMF and other water management ponds will confirm the need for implementing additional treatment measures, such as flocculation for reducing sediment or measures to manage ARD/ML , if required; and
- Maximize water recycle of contact waters and minimize fresh water requirements.

4.2 Hydrologic Methodology and Design Storms

The detailed hydrologic methodology used to develop design storm events for the Project is presented in the Water Management Plan. This section of the ESCP provides a brief overview of relevant components of site water management to erosion and sediment control planning and design.

The methodology used to develop the design storm events for the project area is based on commonly used and accepted standards of practice. Design storm events and flows for the Project site were developed for use in design of the tailings management facility, sizing of watercourse diversion channels, sizing of culverts for access and haul roads, milling and process facilities and sediment control facilities (e.g., sedimentation ponds). Twenty four hour design storm rainfalls in millimetres are presented in Table 4-1 for various return periods for both the mine and port sites

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
	Report No. 504832-0000-4EPA-0005		# PB	Date 2011- 06-24
				36

Table 4-1 - Design Storm 24 Hour Rainfall

Return Period	24 hour Rainfall (mm)	
	Mine Site	Port Site
5	249	226
10	289	272
20	325	323
25	337	340
50	371	397
100	403	461
200	435	532
500	475	639
1000	503	Not Calculated
PMP	1300	Not Calculated

4.3 Design Criteria for Sedimentation Control Systems

Stormwater drains, ditches, and stream channels should be protected against erosion through a combination of adequate dimensions, slope limitation techniques, and use of rip-rap and lining. In accordance with the IFC EHS Guidelines for Mining (2007), temporary drainage installations should be designed, constructed, and maintained for recurrence periods of at least a 25-year/24-hour event, while permanent drainage installations should be designed for a 100-year/24-hour recurrence period to comply with. Design requirements for temporary drainage structures should additionally be defined on a risk basis considering the intended life of diversion structures, as well as the recurrence interval of any structures that drain into them.

The World Bank and draft IFC guidelines require that the design and operation of sediment control facilities should meet an effluent TSS discharge limit of 50 mg/L 95% of the time. Panamanian Regulation 351 requires that a TSS limit of 35 mg/L under normal flow conditions be met. The ESIA baseline study on water quality found that as a result of the highly erodible

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	37

saprolitic overburden, combined with high annual rainfall, and frequent intensive events, periodically and naturally elevated TSS concentrations occur within the natural drainage in the project area. TSS concentrations in streams can range from 200 mg/L up to a maximum measured of 1,610 mg/L for periods of heavy rains. Given these results further studies are being undertaken by the project team to assess sediment yields that may be associated with the project. In the interim the project design criteria have been set in accordance with the IFC and Panamanian guidelines.

4.3.1 Diversion Channels

To minimize pit dewatering pumping requirements, as much surface drainage as possible will be diverted from the upstream catchment into ditches with channels located in an upper bench of each of the pits. These channels will be incorporated into the pit walls by creating an extra-wide berm at the appropriate elevation. As the pits grow in circumference over time, the non-contact diversion channels will be modified to accommodate the pit dimensions and natural drainage courses. These diversion channels will be sized to accommodate the 1:100 year 24 hour design storm.

4.3.2 Drainage Ditches

Ditches along the haul, service and access roads, and culverts to convey surface runoff from the waste rock dumps, saprolite stockpiles, plant site and TMF to appropriate sediment treatment facilities are sized to handle the runoff peak and volumes of the catchment area from a 25-year storm event 24 hour storm event.

4.3.3 Sedimentation Ponds

The Sedimentation Pond Facilities will provide temporary storage of the storm water during the construction and pre-development stripping activities. The controlled discharge from these facilities will flow directly into the environment. Collection pond facilities will provide storage of runoff from waste dumps and stockpiles throughout the operational life of the mine. These structures have been sized to accept the 1:10 year 24 hour storm (sedimentation ponds) and 1:100 year 24 hour storm (collection ponds). Spillways for these structures have been designed for the 1:50 year 25 hour storm and the 24 hour PMP respectively.

In addition to storm water design considerations the following criteria have been applied to sedimentation pond (and collection pond) design to address sediment control on a global project:

- Effluent Discharge - The project is being designed for TSS concentration of 50 mg/L 95 % of the time with a normal operational target for 35 mg/L.
- The pond will be designed to provide sufficient storage with the required hydraulic retention time to meet the TSS water quality objective;

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	38

- The pond will be designed to provide sufficient capacity for sediment storage with a provision that dredging may occur every 5 years;
- Ponds will be constructed to store the local runoff. A flow control structure will be installed to gradually release the flow above the dead storage and to provide enough retention time to satisfy the TSS water quality requirement;
- Consideration will be given to installation of flocculant injection and mixing stations in cases where TSS control may be difficult. If necessary, flocculant will be added in the Collection Ponds and Sedimentation Ponds to ensure the TSS water quality requirement is satisfied.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	39

5.0 EROSION AND SEDIMENTATION CONTROL MEASURES

5.1 Introduction

This section provides a summary of erosion and sediment control measures and techniques and their selected application in the construction and operation phases of the Project. As discussed in the previous section, the Water Management Plan will outline the permanent project structures designed to meet the IFC and Panamanian criteria at completion. This plan focuses on providing practices and strategies to be integrated into a planning framework for temporary facilities, or configurations of permanent facilities to allow for the Project to meet compliance targets throughout construction.

5.1.1 Pre-construction Planning

In order to achieve project goals for minimization of erosion and meeting requirements for Total Suspended Sediments (TSS) in discharge streams from the mine property planning of works prior to construction will be critical.

Pre-construction planning for any new area should include a review of existing Issued for Construction drawings of the planned works as well as aerial ortho-photography to identify potential issues related to drainage.

Planning for global erosion and sedimentation control for each watershed affected by construction was conducted along with mine design in the early phase of development for the Project. This included the following engineering design principles for the control of erosion:

- Consideration of site erosion and sedimentation potential during the site selection process for major Project components, such as material stockpiles (i.e., topsoil, saprolite stockpiles), waste rock dumps and plant site, as well as for roads with respect to river-crossing points;
- Ensuring waste rock dumps, and saprolite stockpiles are designed with stable slopes and terraced benches to decrease slopes and flow lengths (thus reducing surface runoff erosion);
- Maintaining and minimizing the removal of existing dense forest and foliage, as feasible for Project components to decrease runoff and sediment loads;
- All stockpiles will be located away from watercourses; temporary stockpiles (stockpiles to be removed during construction) will be located above the 25 year flood level and permanent stockpiles (those remaining following the construction period) will be located above the 100 year flood level;
- Provision for buffer strips of undisturbed ground with vegetation between stockpiles and any active streams to trap and filter suspended solids from stormwater runoff; and

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	40

- Conducting studies to determine sediment characteristics and settling tests of suspended sediment particles to assist in the design of sedimentation ponds; and
- Identification of appropriate sizing requirements for all permanent erosion and sediment control ponds, and provision of general guidelines for the installation of temporary sediment and erosion control measures during construction.

5.1.2 Field Decisions For Implementing Best Management Practices

In addition to these strategies Project Environmental and Construction staff will have to implement field decisions regarding best management practices for construction of temporary sediment and erosion control infrastructure, as well as early works components, especially during site capture phase, when construction term basin protections (sedimentation ponds) are not complete. Proper implementation will require an integrated approach and all activities should be considered in the context of their drainage basin. Permanent controls for each individual basin will be identified on the engineering drawings. Temporary erosion control measures are aimed at controlling sources within individual basins by limiting the amount of area cleared, or applying practices to reduce erosion potential in disturbed areas until permanent structures can be constructed. As progressive areas of each basin are disturbed through the Construction Phase temporary sediment controls in each basin (e.g. check/filtration dams, temporary sediment basins) should be monitored for their effectiveness and adjusted or augmented accordingly.

During construction available local weather forecasts and conditions should be monitored, and should direct selection and scope of the procedures needed to ensure that construction can proceed while still providing effective erosion and sediment control.

To effectively plan these measures all new work will be planned through the JEA process to ensure that erosion and sediment controls (and any other necessary environmental precautions) are adequate to address the new areas. The JEA process is reviewed in full in Environmental Management Systems – Framework (Document 504832-0000-4EPA-0001). In general it consists of three phases:

- Phase 1 – Identification of environmental concerns and planning of mitigation measures prior to the commencement of work activity.
- Phase 2 – Additional concerns identified during construction and corrective actions.
- Phase 3 – Sign off of satisfactory execution of works and effectiveness of mitigation.

The JEA process allows Environmental and Construction staff to work together to address project activities and ensure environmental requirements are understood by the construction teams undertaking particular tasks or activities, or guidance is provided to adjust to field conditions affecting construction activities. It will be used to plan construction activities related to temporary facilities, or as a tool to plan staged work related to the construction of permanent

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	41

facilities where multiple configurations are required. A copy of the JEA process form is attached in Appendix D.

5.2 Erosion and Sediment Control Measures

This section describes the purpose and application of various types of erosion and sediment control measures for implementation during the life of the Project. Section 5.3 describes and illustrates how erosion and sediment control measures will be applied to specific project phases. For further detail regarding installation procedures and typical details refer to the Sediment and Erosion Control - Best Management Practices, provided in Appendix E, the Best Management Practices (Examples from Construction) in Appendix F, as well as the Compendium of Selected Technical Specifications Supporting Earthworks Activities (504832-0000-4EPA-0012).

5.2.1 Erosion Control Procedures

The primary methods of controlling erosion in a work environment which presents the challenges of high rainfall and easily erodible soils are:

- limit the extent of clearing, and especially grubbing and earth moving activities.
- Controlling and directing surface runoff around work areas and away from exposed surfaces.
- Begin establishing long-term protection (revegetation) within 20 days following completion of works.

By restricting these works to areas where construction is set to proceed in a timeframe which minimizes the exposure of soils, the potential for creating environmental (water quality) or structural (erosion damage) issues is similarly minimized. There is no way to eliminate erosion and sedimentation, but the effects can be minimized through the use of a variety of best management practices.

Runoff Control and Velocity Dissipation

In active construction areas the most direct way to minimize erosion and any resultant sedimentation is to control runoff water by diverting it away from erosion prone areas and limiting its velocity where this is not possible. Whenever possible, diversions should direct water to areas which have existing sediment controls in place to further minimize impacts. Another important consideration in linear developments such as pipelines and roads is to prevent the accumulation of flows over long runs as this can cause volumes and velocities to reach levels which are difficult to manage. When applied properly and where possible in advance of the opening of work areas these types of controls can greatly reduce the potential for environmental issues as well as construction delays due to water damage to project infrastructure such as road platforms or dam embankments.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	42

Best management practices which fall into this category include:

- Gabions
- Earth Dyke Barrier
- Brush or Rock Berm
- Check Dam
- Energy Dissipators
- Slope Drains (Temporary Pipes)
- Offtake Ditch (Intercept Ditch)
- Continuous Berm
- Diversion Channel

Slope or Surface Protection

A variety of measures may be employed to protect exposed slopes and surfaces which cannot be revegetated quickly and present an erosion risk. The focus of this type of measure is to break up exposed areas, allowing for increased infiltration and decreased runoff velocities, or to provide protective covering. The selection of a particular method may be dictated by availability of materials, grade of slope, as well as whether or not the site is in final arrangement.

Best management practices which fall into this category include:

- Rip Rap Armouring
- Rolled EC Products (Erosion Control Blankets)
- Slope Texturing/Grading
- Cellular Confinement System
- Fascines, Fiber Rolls and Wattles
- Synthetic Permeable Barrier
- Gravel Blankets
- Soil Tackifiers (Chemical Stabilization)
- Riparian Zone Vegetation (Buffer Zone)

Revegetation

Revegetation provides long term stabilization and protection from erosion. The main priority for initial revegetation of the Project site is the establishment of grasses and shrub-type vegetation to provide erosion control and stabilize the disturbed area. Planting of woody species may be required, following initial implementation of erosion and sediment control measures to reduce edge effects or potential for blowdowns along the edges of disturbed areas which are adjacent to forest habitats/sensitive areas, other than those mentioned above.

Re-establishment of vegetation is required through seeding and/or planting of plugs or other approved vegetative material.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	43

Seeding/Planting of approved species is to take place immediately following re-grading and topsoil/overburden material replacement, which includes the implementation of all temporary/permanent erosion and sediment control measures, but no later than 20 days following these activities. Seed will be applied on all disturbed surfaces unless otherwise specified.

Seeding will be conducted by hand casting, mechanical seeders (hydroseeding, where possible), or mixing with topsoil/overburden/mulch prior to application of soil to trenches, etc. All plugs will be planted by hand. Approved seed mix(es), application rate and method of application will be specified during the JEA process. Work conducted to date and current criteria can be found in Gerencia Ambiental MPSA's *Crterios de Cierre y Rehabilitacion* (PRO-100228) and *Revegetacion* (PRO-100216) technical documents (see Appendix G).

Best management practices which fall into this category include:

- Planting Trees and Shrubs
- Seeding
- Topsoiling
- Mulching
- Seedbank Salvage
- Hydroseeding

5.2.2 Sediment Control Procedures

During the construction and vegetation establishment periods, a significant amount of sediment will be generated, even with best management practices. Sediment ponds will be required downstream of all major construction and disturbed areas to manage the sediment laden waters. These ponds will be detailed in a separate document and will be sized to allow the project to meet discharge criteria. During early works, which will include the construction of these ponds, an effective method of sediment controls is the construction of a series check/filter dams, at intervals along natural drainage courses immediately downstream of construction activities. These are intended to be short term structures and may be designed for settlement or filtration depending on the materials used in construction. It is expected that they will fill with sediment which is why many are placed along the drainage course. Cleaning accumulated sediment will be required once vegetation (or other) erosion control is established.

Best management practices which fall into this category include:

- Straw Bale Barrier
- Silt Fence (Filter Fence)
- Cofferdam
- Sediment Traps and Basins
- Pumped Silt Control Systems
- Turbidity Curtains

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	44

5.3 Procedure Implementation

5.3.1 Introduction

The majority of erosion and sediment control measures identified in the ESCP's for each of the main project components will to be implemented in progressive stages during the construction phase based on Project activities (i.e., clearing and grubbing, site grading, etc.). This section of the ESCP will address them in context of three broad phases of the project: Site Capture, Construction, and Operations.

5.3.2 Schedule

Initial construction will begin with the upgrade of the Llanos Grande Road in June 2011. Construction of the full project will begin following ESIA approval that is expected in the September 2011. Major construction works associated with site capture will begin in January 2012. Construction will extend over a 4 year period of time with site pre-commissioning of the process plant scheduled for late 2015.

Implementation of erosion and sediment controls will be undertaken in concert with the commencement of the first construction activities, such as tree harvesting, clearing and grubbing and site grading.

The operations phase of the Project is expected to occur over a 30-year period, beginning in late 2015.

5.3.3 Site Capture Phase

During the Site Capture phase there will be minimal basin level control of sediments and work activities will consist of initial cutting and clearing, grubbing and initial earthworks for access roads and site facilities. Erosion control and sediment control will be most challenging during this phase, and applying the above strategies and practices in an integrated fashion will be critical to achieving project goals. Prior to quarry development, rock may be available in limited quantities and it is expected that use of debris (brush, mulch) from vegetation clearing will form a core component of strategies, especially on temporary facilities such as geotechnical access roads. In order to achieve project objectives for sediment control constructing series of filtration structures downstream of construction activities until such time as construction term control structures are in place.

5.3.4 Construction Period

During the Construction Phase overall sediment control will be achieved through the secondary structures (sedimentation ponds) constructed as part of Site Capture to provide interim management. Proper erosion control will still be provided by applying the same principles used

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	45

during the site capture phase although material availability of rock may change the practical selection of techniques used in the ongoing site development works.

5.3.5 Operations Phase

In the Operations Phase, erosion and sediment controls will be primarily monitored, maintained and modified, where necessary, to ensure they are working effectively. Overall site sediment control at this stage will be managed via the permanent site infrastructure (e.g. diversion channels, runoff ponds, TMF). Additionally, where practical, disturbed areas and facility features (i.e., saprolite stockpile, waste dumps) will be stabilized during operations as part of the revegetation and mine reclamation plan

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	46

6.0 MONITORING OF CONTROL MEASURES

The erosion and sediment control measures installed, in accordance with the ESCP, will be monitored and maintained throughout the construction and operational phases of the Project. Monitoring will involve regular visual inspections of erosion and sediment control measures at the following areas, as a minimum.

- Topsoil stockpiles;
- Waste rock storage facilities;
- Waste dumps and moats;
- Open pit and mine site area;
- Diversion channels;
- Site access, service and haul roads, including ditches;
- Plant site area;
- Tailings management facility; and
- Areas associated with ancillary infrastructure (quarry, landfill, tailings lines).

6.1 Parameters and Measures of success

One of the primary roles of Environmental Inspectors during construction will be to oversee Contractors to ensure that specified erosion and sediment control devices and other protection measures are implemented and working effectively. In the early stages of construction this includes controlling sediment from vegetation clearing activities and ensuring that buffer zones of undisturbed vegetation are maintained between the construction areas and watercourses and other environmentally sensitive areas, as required. In addition, Environmental Inspectors will ensure that best management practices are implemented, such as ensuring proper segregation of topsoil for subsequent use in progressive site stabilization and final rehabilitation activities.

Visual inspections of topsoil stockpiles, saprolite stockpiles, and waste storage areas (including moats) will be conducted to view the slopes for signs of erosion (i.e., gully, rill or slumping), as well as the integrity of erosion and sedimentation control measures. This monitoring will also include evaluation of erosion with respect to any interim stabilization and sedimentation control efforts which will be required (e.g., waste rock storage areas).

The monitoring of sedimentation ponds will include regular site inspections to assess:

- Sediment accumulation to determine need for clean-out;
- Water level and discharge quality (discussed further in Section 6.2.1);
- Seepage through fill embankment and overall stability;
- Functioning of outlet structure (e.g., perforated riser pipe); and

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	47

- Performance and effectiveness of flocculent treatment, if applicable.

In the event that water quality monitoring results for ponds exceed IFC's (50 mg/L) effluent standards for TSS, the use of flocculants will be considered to reduce TSS levels to acceptable concentrations. .

Sediment and erosion control monitoring will also be applied to assess:

- The treatment of dewatering effluent;
- The effectiveness of rock check /brush dams and silt fence/brush barriers;
- Compliance with the environmental protection measures specified for watercourse crossings or diversions; and
- Stabilization of disturbed areas, where erosion control measures are present, including aggregate lining, erosion control blanket and seed and mulch.

Monitoring will also include verification that specified measures are installed and maintained in accordance with the construction specifications for the Project.

In addition to regular inspections, monitoring will focus on viewing control measures during and immediately after storm events. As part of the Project's monitoring program, water quality sampling for TSS will be conducted at receiving watercourses and at sedimentation ponds to provide an indication of the overall effectiveness of site erosion and sedimentation control measures.

As part of the monitoring program, test may be undertaken on stockpiled soils, to identify their suitability as a soil cover or topsoil amendment in the establishment of vegetation. In addition, soil monitoring may also include the collection and analysis of soil samples near the fuel depot/workshop for potential hydrocarbon contamination.

As a result of monitoring, the ESCP established for the project may require amendment throughout the course of the construction and operations period to address areas requiring specific attention or based upon site conditions encountered in view of seasonal weather conditions and significant storm events. The Environmental Manager will be responsible for amendments to the plan and for ensuring that mitigation measures suit specific field conditions, as the construction, operation and closure phases proceed.

6.2 Frequency

During construction all temporary and permanent erosion and sedimentation control measures will be conducted weekly and following any significant rainfall event. For some measures, such as silt fence, inspections should be conducted at least twice per week. Inspection of the saprolite stockpiles and waste dump areas will be undertaken during or immediately after a storm event to check the effectiveness of the erosion and sediment control measures and stability of the dumps and stockpiles. Inspection for slope stability of other stockpiles not active, such as temporary topsoil stockpiles, will be inspected every two (2) weeks.

As construction proceeds the inspection of all permanent erosion and sediment control structures will be conducted weekly and following any significant rainfall event.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	48

6.3 Sampling/Monitoring Locations

Monitoring points for effectiveness of erosion and sediment control measures during construction will be fluid as new areas are opened and other areas are progressively stabilized. Most monitoring will take the form of visual inspections; however, where sampling for parameters such as water quality are deemed appropriate these sampling points will be selected to address the overall effectiveness of a structure or series of structures in controlling sedimentation of watercourses. Sampling and monitoring locations will be established in consultation with MPSA in accordance with requirements of the Environmental Monitoring Plan, (Document 504832-0000-4EPA-0020).

6.4 Maintenance

Maintenance of erosion and sediment control measures will be conducted in accordance with the direction of JVP environmental staff and will be based on the results of the routine monitoring. In general maintenance of slope protection and velocity dissipation or runoff control measures will be on an as needed basis. Sedimentation structures such as temporary sedimentation basins, check dams, berms or silt fence should be cleaned out once levels reach one half the height of the containment to ensure they continue to function as intended. During design and construction of temporary erosion and sediment control measures consideration should be made to allow for adequate access for the necessary equipment to perform appropriate maintenance after its construction.

6.5 Disposal of Removed Sediments

Sediments removed from temporary sedimentation basins, check dams, silt fence as part of regular maintenance may be disposed of as typical excess earth material provided they have been generated by non-contact runoff. For any sediments removed from structures which convey contact water from process areas or waste rock stockpiles they should be disposed of in the tailings management facility.

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	49

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  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	50

Appendix A

Environmental Inspection Form

 Joint Venture Panama Inc.	JOINT VENTURE PANAMA INC.	Report No.:																																
	MINA DE COBRE PROJECT - PANAMA	504832-0000-XXXX-0000																																
Environmental Inspection Report																																		
Purpose:																																		
Contractor: Date: Weather/ Site Conditions:		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="4" style="text-align: center; background-color: #f2f2f2;">General Location</th> </tr> <tr> <td style="width: 25%;">Camp</td> <td style="width: 5%;">☐</td> <td style="width: 25%;">TMF</td> <td style="width: 45%;">☐</td> </tr> <tr> <td>Process Plant</td> <td>☐</td> <td>Quarry # _____</td> <td>☐</td> </tr> <tr> <td>Mine</td> <td>☐</td> <td>Waste Rock Dumps</td> <td>☐</td> </tr> <tr> <td>Pipeline</td> <td>☐</td> <td>Port</td> <td>☐</td> </tr> <tr> <td></td> <td></td> <td>Eastern Access Road</td> <td>☐</td> </tr> <tr> <td></td> <td></td> <td>Coast Access Road</td> <td>☐</td> </tr> <tr> <td></td> <td></td> <td>Transmission Corridor</td> <td>☐</td> </tr> </table>	General Location				Camp	☐	TMF	☐	Process Plant	☐	Quarry # _____	☐	Mine	☐	Waste Rock Dumps	☐	Pipeline	☐	Port	☐			Eastern Access Road	☐			Coast Access Road	☐			Transmission Corridor	☐
General Location																																		
Camp	☐	TMF	☐																															
Process Plant	☐	Quarry # _____	☐																															
Mine	☐	Waste Rock Dumps	☐																															
Pipeline	☐	Port	☐																															
		Eastern Access Road	☐																															
		Coast Access Road	☐																															
		Transmission Corridor	☐																															
Environmental Management Activity	Specific Location	Status Good ☒ Inadequate ☐	Comments / Observations (Attach drawings as required)																															
Clearing and Grubbing		☐																																
Topsoil stockpiles		☐																																
Drainage and Grading		☐																																
Excavations		☐																																
Grading – fill/cut slopes		☐																																
Water conveyance/drainage ditches		☐																																
Dewatering		☐																																
Discharge Diffusers		☐																																
Sediment Trap/Basin		☐																																
Erosion and Sediment Control		☐																																
Silt Fences/ Brush Barriers		☐																																
Rock Check Dam/ Brush Dam		☐																																
Sedimentation Ponds		☐																																
Seeding/ revegetation		☐																																
Erosion Control Blanket		☐																																
Aggregate Lining		☐																																
Plastic sheeting		☐																																
Temporary Diversion/Pump Around		☐																																
Coffer Dam		☐																																
General Construction		☐																																
Dust Suppression/control		☐																																
Noise Control		☐																																
Fuel Handling/Storage/Vehicle Maintenance		☐																																
Solid Waste Handling and Storage		☐																																
Hazardous Waste Handling and Storage		☐																																
Slash and earth stockpiles		☐																																
Archaeological/Cultural resources		☐																																
Access Roads		☐																																
Protection measures for sensitive areas		☐																																
Other		☐																																
Environmental Inspector:		Signature:	Date:																															

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	52

Appendix B

Non-Compliance Report

	JOINT VENTURE PANAMA INC.	Report No.:
	MINA DE COBRE PROJECT- PANAMA	504832-0000-XXXX-□□□□
Non-Compliance / Non Conformity Report - Environment		

LOCATION:	CONTRACTOR:	DATE:	SITE CONDITIONS:

DESCRIPTION OF WORK/ UNDERTAKING: (Type of work, activity or environmental specifications/procedures)	
DESCRIPTION OF DEFICENCY / NON-COMPLIANCE (Attach drawing(s) and location map):	
JVP Environmental Inspector	Signature/Date:

DESCRIPTION OF REQUIRED CORRECTIVE ACTION:	
ACTION REQUIRED BY (DATE):	
Contractor	Signature/Date
JVP Environmental Superinendent/Inspector	Signature/Date
JVP Construction Superintendent	Signature/Date

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	53

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	54

Appendix C

Environmental Incident Report

INSTRUCTIONS:

The Risk Analysis at Work (ART) is used to evaluate construction and operations activities by using a category of risks consisting of 5 levels of possibility and consequences as presented below.

Before preparing the environmental incident report, the Risk Analysis at Work (ART) must be completed. If the **Consequence of the event** is rated as “*low*” (low (1)) or “*minor*” (2)) complete only sections **1: Basic Data** and **2: Incident Description** of the Environmental Incident Report.

If the **Consequence of the event** is rated as “*moderate*” (3), “*major*” (4) or “*catastrophic*” (5), complete the entire Environmental Incident Report.

Matrix of Risk Evaluation						
Possibility		Consequences				
		Low (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
	Certain (5)	M 5	A 10	E 15	E 20	E 25
	Probable (4)	M 4	A 8	A 12	E 16	E 20
	Possible (3)	B 3	M 6	A 9	A 12	E 15
	Unlikely (2)	B 2	B 4	M 6	A 8	A 10
	Rare (1)	B 1	B 2	B 3	M 4	A 5
B – Low, M – Medium, A – High, E - Extreme						
Evaluation of Consequences and Possibilities Consequence- the most likely outcome in case of exposure to the event Catastrophic: Fatality (s), a long-term environmental impact, the community suffers irreparable adverse impact or, the survival of the operation was threatened Major: Permanent disability, significant environmental impact is reversible, the community suffers significant adverse impact, material change in the financial condition of the operation. Moderate: Lost time injury, short-term environmental impact, the community suffers adverse impact, no material change in financial condition. Minor: Medical treatment, minimal environmental impact, the community suffers minor adverse impact, negligible change in the financial condition of the operation. Low: First Aid Treatment, normal variation of an operation that impact the environment, local community concerns, no adverse financial impact. Possibility – How often the event is expected to occur with the resulting consequence. Certain: it is expected to occur in most circumstances,> once a month. Probable: almost certain to occur in most circumstances, 1-2 years. Possible: may occur at any time, 2-10 years. Unlikely: May occur at any time, 10-20 years. Rare: May occur only in exceptional circumstances,> 20 years.						



1 BASIC DATA		All details shall be provided.
Who reported Incident – Name	ID No:	
Date of Incident	Time of Incident	
Supervisor responsible – Name	ID No:	
Location of Incident		
2 INCIDENT DESCRIPTION		Inspect scene of incident and make area safe. Describe briefly what occurred, including Incident Level I, II or III, and , if a spill, amount spilled. Note the duration of the incident. .
Was anyone injured (Y/N)		
ID No:	Name:	Injury:
ID No:	Name:	Injury:
ID No:	Name:	Injury:
ID No:	Name:	Injury:

Environmental Incident Report

3 CONSEQUENCES - ACTUAL & POTENTIAL				If this occurrence happened again what <u>realistically</u> is the worst outcome that could occur? 0 - No Damage / No Injury 1 - Minor local isolated damage 2 - Significant local consequences 3 - Serious extended impacts 4 - Catastrophic Environmental Damage								
Please enter (0-5) for all Actual & Potential outcomes <table> <tr> <td>Personnel Safety:</td> <td>Actual:</td> <td>Potential:</td> </tr> <tr> <td>Plant/Equipment Damage:</td> <td>Actual:</td> <td>Potential:</td> </tr> <tr> <td>Environment:</td> <td>Actual:</td> <td>Potential:</td> </tr> </table> Indicate where applicable nature and extent of potential environmental damage, or consequences of environmental damage.					Personnel Safety:	Actual:	Potential:	Plant/Equipment Damage:	Actual:	Potential:	Environment:	Actual:
Personnel Safety:	Actual:	Potential:										
Plant/Equipment Damage:	Actual:	Potential:										
Environment:	Actual:	Potential:										
4 LIST OF KNOWN WITNESSES TO INCIDENT				List all witnesses								
ID No:	Name:	ID No:	Name:									
ID No:	Name:	ID No:	Name:									
ID No:	Name:	ID No:	Name:									
ID No:	Name:	ID No:	Name:									
ID No:	Name:	ID No:	Name:									

MINA DE COBRE PANAMA	INCIDENT REPORT	Nº
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**Entered into the project
register by:**

Write the Incident No. on the top of the document



Pin/staple
additional info
here

INCIDENT INVESTIGATION

7 FACTS RESULTING FROM THE INVESTIGATION

Interview those involved – including witnesses – Note Time and Location – Environmental Conditions – Type of material spilled if a spill – Position of people, equipment & materials – Directions Given – Anything moved, turned on/off or taken from the scene – Actions of person prior, during and after.

Record Details – Scene – Diagram and Photos – Statements – Sequence of events – Experience/Training instructions given – Possible effects on people/environment, using MSDS. Develop Time Line. Attach additional material as appropriate (including site map indicating where incident occurred and MSDS for material spilled).



Joint Venture Panama Inc.

Environmental Incident Report

MINA DE COBRE PANAMA	INCIDENT REPORT	Nº
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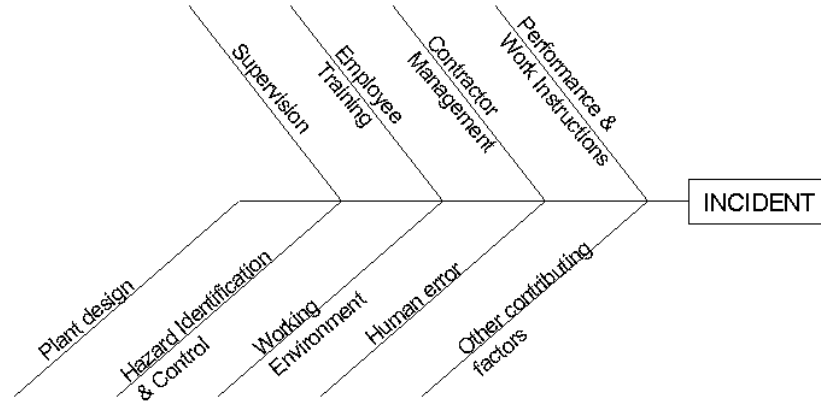
What led to this incident?

Identify root cause(s) and contributory factors.

Use "Ask WHY 5 times", Cause and Effect diagrams and/or Tripod Analysis.

List the analysis process and the root causes, including the fallible decisions and the system failures.

7 CAUSE ANALYSIS



MINA DE COBRE PANAMA	INCIDENT REPORT	Nº
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Corrective action shall address root cause(s) and eliminate or reduce the probability of a re-occurrence. If the corrective action cannot be authorised and/or implemented within 3 working days of the completion of the investigation, the Lead Investigator shall raise a Corrective Action on the most appropriate person / organisation. Ensure that action is taken to institutionalise the remedial action across the project. Indicate where contaminating material was shipped to, if applicable (attach order forms, bills, etc.)	8 CORRECTIVE ACTION		
	Corrective Actions	Responsibility (Person & Date)	CAR No. (if applicable)
Provide any additional comments that are not covered elsewhere. If there is any doubt about the circumstances of an accident i.e.; fraud, then contact Safety Manager A.S.A.P. If an inquiry is involved, notify Manager HR of any unusual findings.	9 COMMENTS BY PERSON INVESTIGATING		
	I am satisfied that to the best of my knowledge, the incident occurred as described. YES ☐ NO ☐ Investigators Name: _____ Investigators Signature: _____ Date: ____ / ____ / ____		

MINA DE COBRE PANAMA	INCIDENT REPORT	Nº
-----------------------------	------------------------	-----------

INCIDENT CLOSURE

Corrective action shall address root cause(s) and eliminate or reduce the probability of a re-occurrence. If the corrective action cannot be authorised and/or implemented within 3 working days of the completion of the investigation, the Lead Investigator shall raise a Corrective Action on the most appropriate person / organisation. Ensure that action is taken to institutionalise the remedial action across the project.	10 COMMENTS BY INVESTIGATION TEAM LEADER I am satisfied that all reasonable steps have been taken to - (please click) ☐ Thoroughly investigate the Incident. ☐ Identify root causes ☐ Identify and implement corrective action. ☐ Institutionalise the fix. This investigation will be reviewed by (date) to ensure the corrective actions have been implemented and are effective Reviewed by _____ Signature: _____ Date / /
Provide any additional comments that are not covered elsewhere. If there is any doubt about the circumstances of an accident i.e.; fraud, then contact Manager Safety A.S.A.P. If an inquiry is involved, notify Manager HR of any unusual findings.	11 REVIEW BY CONSTRUCTION MANAGER Reviewed by _____ Signature: _____ Date / /



Environmental Incident Report

MINA DE COBRE PANAMA	INCIDENT REPORT	Nº
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For all lost time injuries and Level 2 Incidents and above, the Project Manager will review investigation to ensure as far as reasonably practical that all steps have been taken to prevent a re-occurrence. Project Manager as "Responsible Officer" is to be satisfied that as far as reasonably practicable, all steps have been taken to prevent a re-occurrence of the incident.	12 COMMENTS BY PROJECT MANAGER
	Signature: _____ Date / /

In the day following the incident, send a copy of this report to the Business Unit Environmental Director/Coordinator.

Sent: ☐

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	55

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	56

Appendix D

Job Environmental Analysis Form

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	57

Prepared/ Issued by:	Name	Title	Date
Contractor:			

Defined Work Area/Activity (attach drawing):	
Scope of Work:	

Personal Protective Equipment (PPE):	
All personnel are required to wear hard hats, safety glasses, and orange reflective work vest at all times. Additional required PPE includes:	
1.	4.
2.	5.
3.	6.

Total Area Disturbed: _____ ha

Areas of concern (specify location – attach drawings):				
Areas	ha		Areas	ha
1. _____			8. _____	
2. _____			9. _____	
3. _____			10. _____	
4. _____			11. _____	
5. _____			12. _____	
6. _____			13. _____	
7. _____			14. _____	

I (contractor's name) have read and understand the Minimum Environmental Requirements for Construction and will implement environmental protection procedures into daily work activities.

Date: _____

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
	Report No. 504832-0000-4EPA-0005		#	Date	
			PB	2011- 06-24	58

General Requirements:

Flora and Fauna relocation has been completed.

Compliance with all applicable permits (see below).

No activities to be conducted outside of designated working area as shown on drawings.

Wildlife is not to be harassed or fed.

Applicable Legislation/Standards/Codes/Permits:

Identification No.	Title

Environmental Sensitivities and Preventative Actions

<i>Area</i>	<i>of</i>		
Sensitivities/Potential Hazards	Preventive Actions	Responsibility	

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	59

Social Sensitivities and Required Actions			
Area of Concern	Required Actions	<u>Responsibility</u>	Date Required By:
Specific measures employed to ensure protection of the physical, biological and social environment during construction (in ordered sequence)			

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	60

1.	
2.	
3.	
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Work Activity Schedule		
Activities	Schedule Dates	
	Planned Dates	Effective Dates

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	61

This JEA has been reviewed and discussed with the following:			
Date	Name (print)	Position/Title	Signature
		JVP Construction Representative	
		JVP Environmental Representative	
		Contractor	

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	62

PART 2 – Additional Information

This section provides additional information on the environmental sensitivities/ preventative work procedures that may be obtained or identified following the initiation of the work activities discussed above. Drawings should be attached for each additional issue identified.

Environmental and Social Sensitivities and Required Actions				
No.	Area of Concern	Required Actions	<u>Responsibility</u>	Date Actions Implemented
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	63

Additional environmental and social sensitivities/issues identified following the initiation of the work described herein has been reviewed and discussed with the following:

Date	Name (print)	<u>Position/Title</u>	Signature
		JVP Construction Representative	
		JVP Environmental Representative	
		Contractor	

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	64

PART 3 – JEA Finalization

This section is to be completed once work/activity is finalized.

Where work is not in compliance with JEA, issues are to be addressed through the Non-Compliance Reporting Structure.

JEA Finalization		Comments / Observations
Final Environmental Inspection of the work/activity completed	☐	
Work / activity have been carried out in compliance with JEA.	☐	

Name

Signature

Date

Contractor:

**JVP
Environmental
Representative:**

**JVP
Construction
Representative:**

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	65

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	66

Appendix E

SEDIMENT AND EROSION CONTROL

BEST MANAGEMENT PRACTICES

Rolled Erosion Control Products (RECP)

Slope and Surface Protection

BMP 1

Description and Purpose

- Biodegradable or synthetic soil coverings used for temporary or permanent protection of disturbed soils at slopes and channels
- Categories of Rolled Erosion Control Products (RECP) can be:
 - Erosion control blankets (ECB) (generally biodegradable and temporary)
 - Turf reinforcement mats (TRM)
 - Composite turf reinforcement mats (C-TRM)
- RECP may be manufactured of organic material, synthetic material, or as a composite of organic and synthetic materials
- Protect disturbed soils from raindrop impact and surface runoff erosion, increase water infiltration into soil, retains soil moisture and decreases evaporation loss
- Protect seeds from raindrop impact, runoff, and predators
- Stabilize soil temperature to promote germination and enhance vegetation growth

Applications

- Temporary or permanent measure
- May be used to protect disturbed, exposed soils for cut or fill slopes at gradients of 2.5H:1V or steeper
- May be used on slopes where erosion potential is high
- May be used on slopes where vegetation is likely to develop slowly
- May be used to protect disturbed exposed soils in ditches and channels by providing additional tractive resistance cover in conjunction with high density vegetative growth

Advantages

- Degree of erosion protection is higher, more uniform, and longer lasting than for
- sprayed-on products (e.g. mulches)
- Wide range of available temporary (biodegradable) or permanent products

Limitations

- Non-performance of RECP may result from the following:
 - Low density vegetation growth (beneath RECP) due to non-favorable weather and growth conditions (i.e. soil type, moisture, storm events at critical times). The effectiveness of RECP, especially along channels, is dependent on successful vegetation growth. It is important that the designer assess the effectiveness of RECP for site-specific soil, terrain and vegetation growth conditions.
 - Hydraulic uplift of RECP and erosion of underlying soils can occur under rapid snow melt conditions when dammed melt water generates a hydraulic head and high flow velocity in a constricted snow melt channel. This situation can occur along steep channels interlaced with drop structures and with RECP lining installed in between the drop structures. Ponding of melt water and non anchored RECP joint areas allow flow entry beneath the RECP and generate hydraulic heads to uplift the RECP. This can occur along un-anchored edges of RECP at upper edges of ditch when snow melt occurs at tops of ditch and flow beneath the RECP. This is especially critical when underlying soil is easily erodible. It is important to trench-in and anchor the edges of the RECP installations and installed anchor pin (staples) at sufficient frequent intervals.
 - Ice buildup from groundwater seepage can uplift and dislocate the RECP and cause flow beneath the RECP to erode the substrate soils. Winter ice accumulation may be related to groundwater regime and investigative design on subsurface drainage by a geotechnical engineer is required.
- Can be labour intensive to install
- Must be installed on unfrozen ground
- Temporary blankets may require removal before permanent measures are installed

Rolled Erosion Control Products (RECP)

Slope and Surface Protection

BMP 1

- Rolled erosion control products (RECP) are not suitable for rocky sites
- Proper surface preparation is required for intimate contact between blanket and soil. Plastic sheeting can be used at sensitive slopes with precautions:
 - Plastic sheeting RECP product can be easily torn, ripped, non-biodegradable, and should be disposed of in a landfill
 - Plastic sheeting product, if used, results in 100% runoff, thus increasing erosion potential in downslope areas receiving the increased flow volumes
 - Plastic sheeting should be limited to temporary covering of sensitive soil stockpiles or temporary covering of small critical unstable slope areas

Construction (Slopes)

(Note: For guidance only. A site specific design is required from designer/engineer.)

- RECP should be installed in accordance with manufacturers directions
- The following is a general installation method:
 - Prepare surface and place topsoil and seed
 - Surface should be smooth and free of rocks, debris, or other deleterious materials
 - Blanket should be anchored at top of slope in a minimum 0.15 m by 0.15 m trench for the entire width of the blanket
 - The blanket should be rolled out downslope
 - Where the blanket roll is not long enough to cover the entire length of the slope, a minimum 0.15 m by 0.15 m check slot should be excavated at the location of the lap, and the downslope segment of blanket anchored in the check slot, similar to the method used for the top of the slope, or (2) when blankets, must be spliced down the slope, place blanket end over end (shingle style) with approximately 0.10 m overlap. Staple through overlapped area at 0.3 m intervals.
 - The upslope portion of blanket should overlap the downslope portion of blanket, shingle style, at least 0.15 m with staple anchors placed a maximum 0.3 m apart
 - Adjacent rolls of blanket should overlap a minimum 0.1 m
 - Anchors should be placed along central portion of blanket spaced at 4/m² minimum (0.5 m spacing) for slopes steeper than 2H:1V and 1/m² (1 m spacing) for slopes flatter than 2H:1V
 - Anchors along splices between adjacent rolls should be placed 0.9 m apart

Construction (Channels)

(Note: For guidance only. A site specific design is required from designer/engineer.)

- A blanket should be installed in accordance with manufacturers directions
- The following is a general installation method:
 - Prepare surface and place topsoil and seed
 - Surface should be smooth and free of large rocks, debris, or other deleterious materials
 - Begin by excavating a minimum 0.15 m deep and 0.15 m wide trench at the upstream end of channel and place end of RECP into trench
 - Use a double row of staggered anchors approximately 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
 - Backfill and compact soil over RECP in trench
 - Roll centre RECP in direction of water flow on base of channel
 - Place RECP end over end (shingle style) with a minimum 0.15 m overlap downgrade
 - Use a double row of staggered anchors approximately 0.1 m apart to secure RECP to soil
 - Full length edge of RECP at top of sideslopes must be anchored in a minimum 0.15 m deep and 0.15 m wide trench
 - Use a double row of staggered staple anchors a maximum of 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
 - Backfill and compact soil over RECP in trench
 - Overlap RECP on sideslopes (shingle style down channel) a minimum of 0.1 m over the centre RECP and secure RECP to soil with anchors spaced a maximum of 0.2 m apart

Rolled Erosion Control Products (RECP)

Slope and Surface Protection

BMP 1

- In high flow channels, a check slot across the width of the channel is recommended at a maximum spacing of 10 m to anchor the ends of the RECP to the underlying soil
 - Use a double row of staggered staple anchors a maximum of 0.1 m apart (0.2 m linear spacing) to secure RECP to soil in base of check slot
 - Backfill and compact soil over RECP in check slot
- Anchor terminal ends of RECP in a minimum 0.15 m deep and 0.15 m wide trench
- Use a double row of staggered anchors a maximum of 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
 - Backfill and compact soil over RECP in trench

Construction Considerations

- Slopes should be topsoiled and seeded prior to placing RECP
- Ensure blanket is in intimate contact with the soil by properly grading soil, removing rocks or deleterious materials, prior to placing blanket
- In channels, blankets should extend above the anticipated flow height, with a minimum 0.5 m of free board
- For turf reinforcement mat (TRM), blanket should be placed immediately after topsoiling
- Blanket should be anchored by using wire staples, metal geotextile stake pins, or triangular wooden stakes
 - All anchors should be a minimum of 0.15 to 0.20 m in length
 - For loose soils, use longer anchors
- Blankets should be placed longitudinal to direction of flow, with fabric not stretched but maintaining contact with underlying soil
- It is essential to understand product specifications and follow manufacturers instructions on installation methods

Product Quality Assurance/Quality Control (QA/QC) Certification

RECPs should be certified by the supplier/manufacturer to ensure product performance and compliance with specified property requirements. A certificate for QA/QC testing of manufactured products is required. The performance and QA/QC testing should be carried out by reputable laboratories to ensure a commonly acceptable QA/QC standard. Depending on product type and intended performance, the product information certificate should be provided by the product supplier/manufacturer and include the following:

- Performance specification:
 - Permissible Tractive Resistance (include testing methods and vegetative growth conditions)
 - Permissible Flow Velocity (if available)
 - Longevity (for biodegradable or non-biodegradable products)
- Minimum Average Roll Values (MARVs) along with specified testing methods for:
 - Physical properties
 - Mass per unit area
 - Thickness
 - Tensile strength
 - UV Resistance
 - Other physical properties (for non-woven below Erosion Mat (if specified))
 - Grab tensile strength
 - Grab elongation
 - Puncture strength
 - Trapezoidal tear
 - UV Resistance

Inspection and Maintenance

Rolled Erosion Control Products (RECP)

Slope and Surface Protection

BMP 1

- Area covered with blankets should be regularly inspected/repared, especially after periods of severe rainfall or storm events, to check for blanket separation or breakage
- Any damaged or poorly performing areas should be repaired immediately. Regrading of the slope by hand methods may be required in the event of rill or gully erosion.
- Inspection and maintenance should continue until dense vegetation is established
- Areas with low vegetation density should be reseeded
- After approximately one year, a top dressing of fertilizer may be applied to improve vegetation cover and assist degradation of temporary blankets

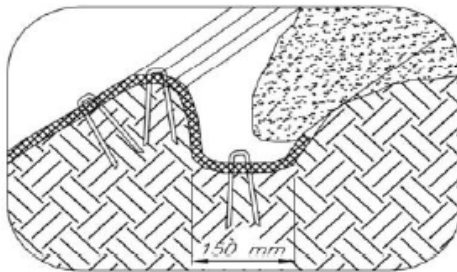
Similar Measures

- Mulching (for slopes only)
- Chemical stabilization (for slopes only, e.g. tackifiers)
- Rip rap (primarily in channels)
- Gabion mattresses (primarily in channels)
- **Design Considerations**
 - Assess hydraulic flow conditions and tractive stress on channel
 - Assess local soil, weather and growth conditions (favourable/non-favourable) for revegetation (within 3 to 12 months) to allow a determination on use or non-use of RECP as a protective measure. If the revegetation conditions are assessed favourable, the use of RECP can be considered
 - Assess suitability of a RECP product using tractive resistance data tested for (i) bare soil, and (ii) vegetated (a specified duration of growth period) condition
 - It is noted that tractive resistance data are adopted as selection criteria of RECP and permissible velocity data can be provided for reference.

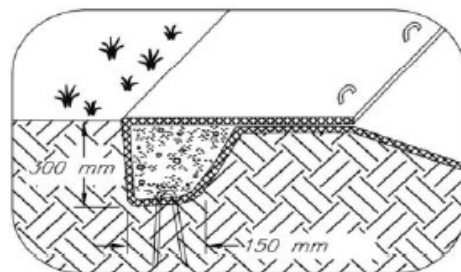
Rolled Erosion Control Products (RECP)

Slope and Surface Protection

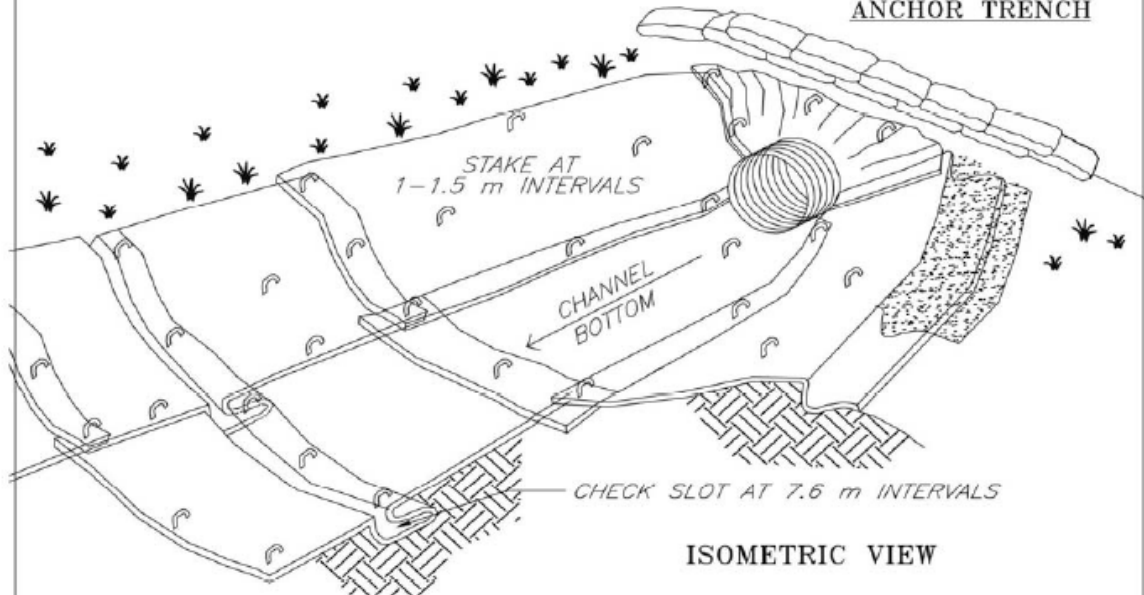
BMP 1



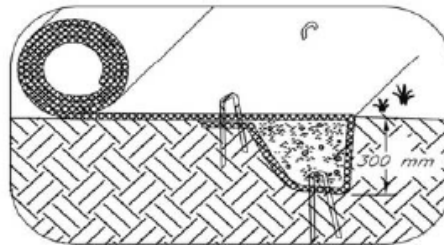
LONGITUDINAL ANCHOR TRENCH



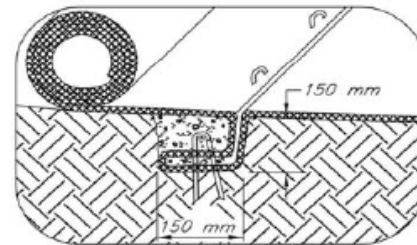
TERMINAL SLOPE AND CHANNEL
ANCHOR TRENCH



ISOMETRIC VIEW



INITIAL CHANNEL ANCHOR TRENCH



INTERMITTENT CHECK SLOT

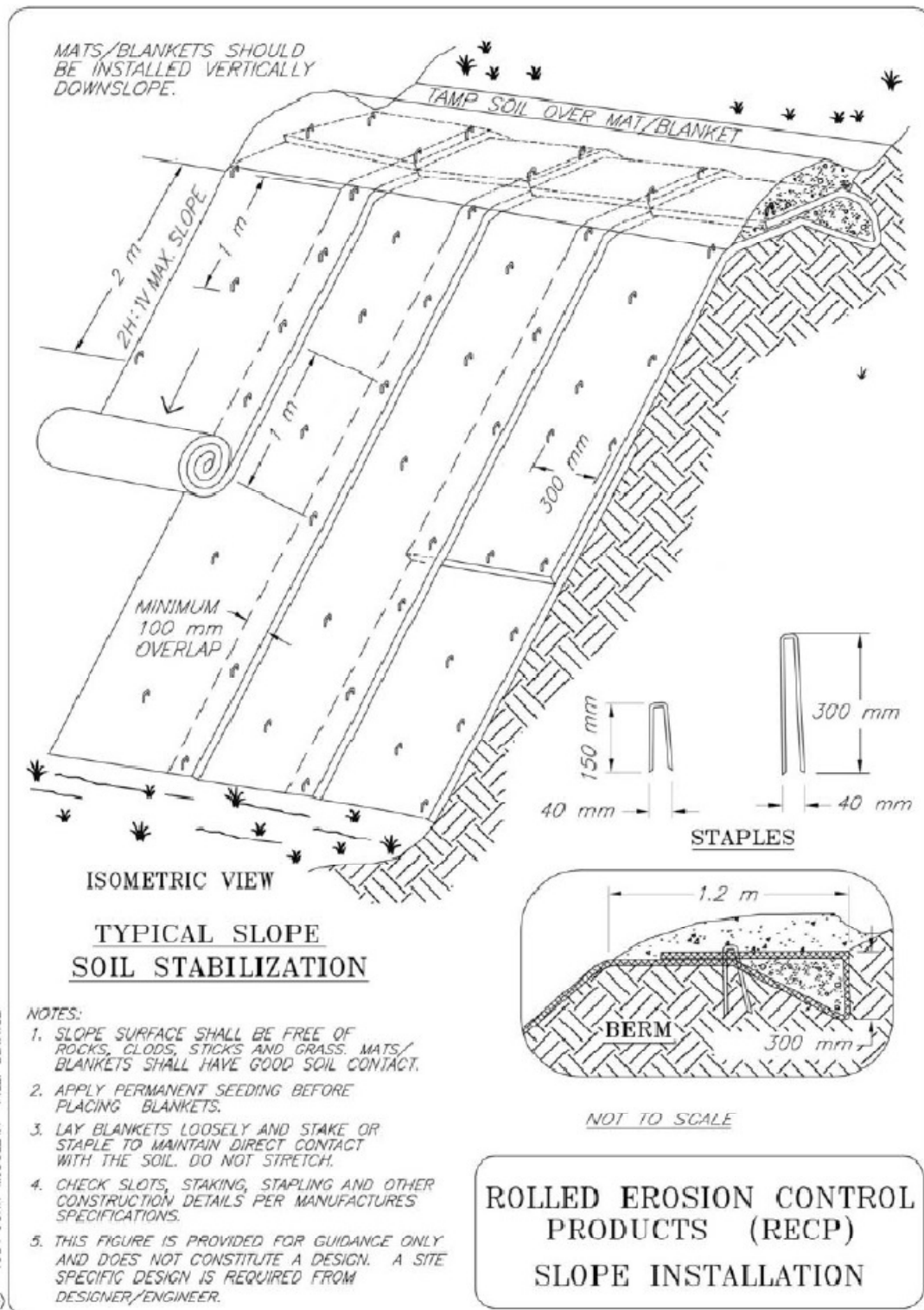
NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**ROLLED EROSION CONTROL
PRODUCTS (RECP)
CHANNEL INSTALLATION**

Rolled Erosion Control Products (RECP) Slope and Surface Protection

BMP 1



Description and Purpose

- Large, loosely placed cobbles or boulders placed along channel banks or slopes to protect underlying soil from erosion due to flowing water
- Can protect slopes and channel banks against erosion

Applications

- Permanent measure
- May be used on channel banks and slopes with flow velocities ranging from 2 m/s to 5 m/s (dependent on rock size and thickness); appropriate for slopes that do not exceed 2H:1V
- Riprap only needs to be placed at lower portion of channel section to the anticipated flow height (mean annual peak flow) plus freeboard; other forms of soft armouring (RECP blankets, seeding) can be used to promote vegetation to protect soil at upper portion of channel slopes, above riprap
- Must be used in conjunction with a non-woven geotextile or filter gravel underlay acting as a filtration separator with basal soil
- For fluctuating high flow channel, the riprap should be underlain by a layer of granular filter material for cyclic drawdown long-term performance with/without an extra layer of non-woven geotextile as underlay

Advantages

- Easy to install and easy to repair
- Very durable, long lasting, and virtually maintenance free
- Flexible

Limitations

- Expensive form of channel lining and stabilization
- Requires heavy equipment and transport of rock to site
- May not be feasible in areas where suitable rock is not available
- Riprap may have to be placed by hand
- Normally 2 to 3 times riprap thickness is required in comparison with gabion mattress thickness for equivalent protection performance under identical hydraulic conditions

Construction

(Note: For guidance only. A site specific design is required from designer/engineer.)

- Grade the slope or channel to final design grade
- Place filter (underlay) layer on prepared slope; filter layer can consist of non-woven geotextile underlay and/or well graded granular material dependent on hydraulic conditions
- Place riprap layer

Construction Considerations

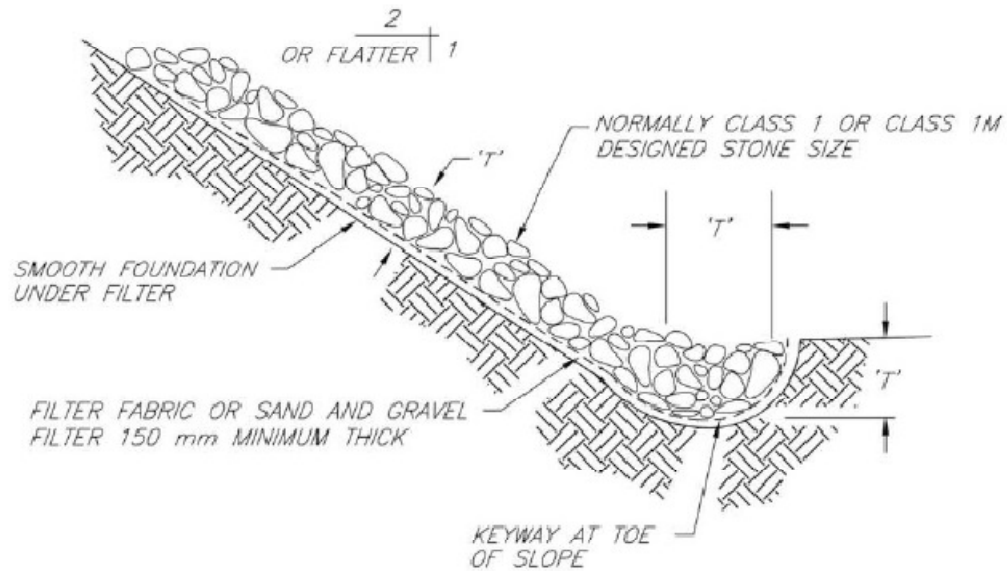
- Riprap should be placed in a uniform thickness across the channel so as not to constrict channel width
- Blasted rock is preferred (if available)
- Riprap layer should be 1.5 to 2 times the thickness of the largest rocks used, 1.5 to 3 times the thickness of the d50 material, and not less than 300 mm in thickness

Inspection and Maintenance

- Little maintenance is required
- Periodic inspections to check for erosion of protected material or movement of riprap

Similar Measures

- Rolled erosion control products (RECP) well vegetated; not for use at severe flow and high velocity areas
- Gabion mattresses



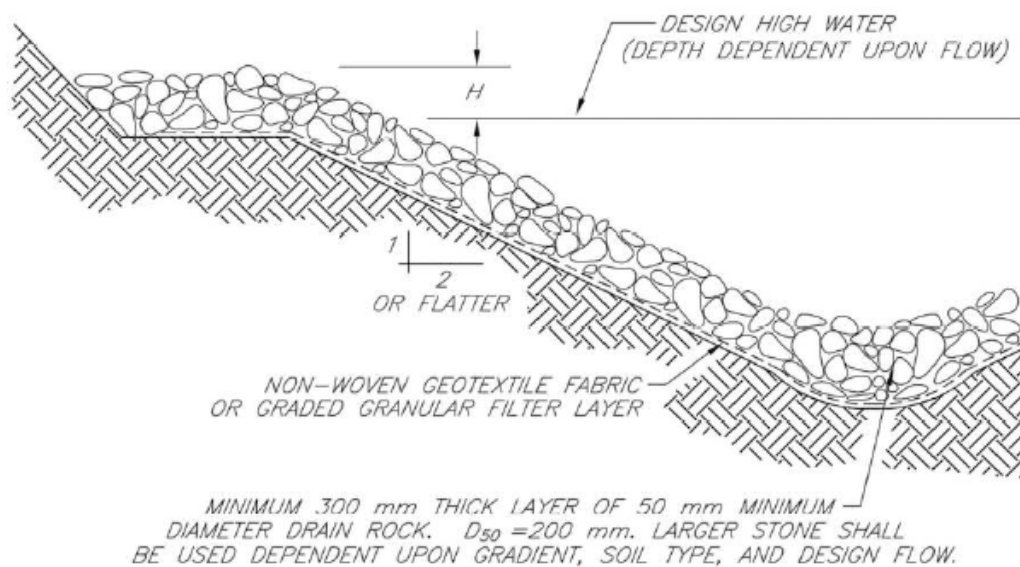
TYPICAL SECTION

NOTE:

1. 'T' = THICKNESS: THICKNESS SHALL BE DETERMINED BY THE ENGINEER.
MINIMUM THICKNESS = 300 mm. (i.e. $1.5 \times D_{50}$) FOR $D_{50} = 200$ mm.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**RIPRAP
ARMOURING
FOR SLOPE**

DESIGN HEIGHT (H), WIDTH AND STONE SIZE SHALL
BE DETERMINED BY THE ENGINEER



TYPICAL SECTION

NOTES:

1. RIPRAP GRADATION AND THICKNESS SHALL BE DETERMINED BY THE ENGINEER IN ACCORDANCE WITH HYDRAULIC CONDITIONS.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**RIPRAP
ARMOURING
FOR CHANNEL**

Slope Texturing / Grading

Slope and Surface Protection

BMP 3

Description and Purpose

- Texturing of slopes, either by roughening the surface, tracking the surface, or installing grooves or serrations
- Texturing reduces the runoff velocity, traps sediment, and increases the infiltration of water into the soil

Applications

- Temporary or permanent measure
- May be used to roughen the exposed soils on the slope surface in the direction of water flow to minimize erosion and to entrap some sediments
- May be used on fresh cut or fill slopes (8 m length or longer practical travel reach of dozer) with gradients of generally 3H:1V or steeper (2H:1V as general steepness limit) constructed in cohesive soils
- May be used on slope subgrade that will not be immediately topsoiled, vegetated or otherwise stabilized
- May be applied to topsoiled slope to provide track serration to further reduce erosion potential
- May be used in graded areas with smooth and hard surfaces
- Benching of slopes is discouraged for a number of reasons. Benches increase local slope gradients over those which can be achieved without benches. Ponding and discharge from benched areas can concentrate flows and result in gully erosion. If benches must be installed for equipment access, it is important that positive downslope gradients are constructed in all areas.

Advantages

- Reduces erosion potential of a slope
- Texturing will create protrusions to increase surface roughness to reduce overland flow velocities and erosion energy
- Texturing will create minor spaces to entrap a portion of the coarse sediment and reduces amount of sediment transported downslope
- Texturing of slopes will benefit development of vegetation
- Texturing of slopes aids in performance of mulches and hydroseeding
- Texturing with track-walking up/downstream may effect a 10% reduction of sediment yield compared with untracked slope

Limitations

- Surface roughening and tracking may increase grading costs
- Surface roughening and tracking may cause sloughing in certain soil types (i.e. sandy silt) and seepage areas; geotechnical advice is recommended
- Texturing provides limited erosion and sediment control and should be used as a temporary measure prior to topsoiling
- Texturing should be used in conjunction with other erosion and sediment control
- measures (i.e. offtake ditches) to limit the downslope sheet flow

Construction

(Note: For guidance only. A site specific design is required from designer/engineer.)

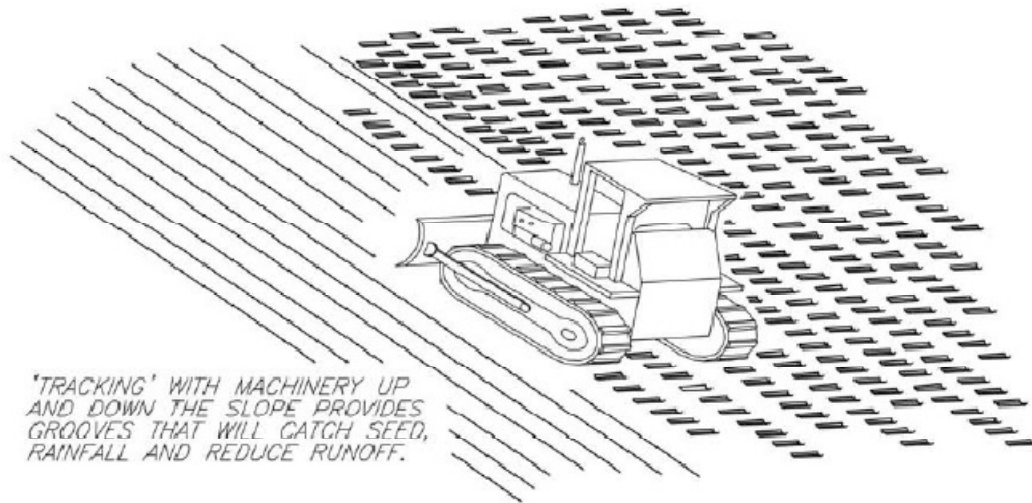
- Surface Roughening
 - Leave soil in rough grade condition, do not smooth grade soil
 - Large lumps of soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Surface Tracking
 - Using tracked construction equipment to move up and down the slope, leaving depressions perpendicular to the slope direction; limit passes to prevent overcompaction of the surface

Slope Texturing / Grading <i>Slope and Surface Protection</i>	BMP 3
---	--------------

- Depressions in the soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Grooving
 - Excavating shallow furrows across the width of the slope, perpendicular to the direction of the slope
 - If used, contour grooves should be approximately 0.1 to 0.2 m in depth
- Grooves can be made by using equipment or hand

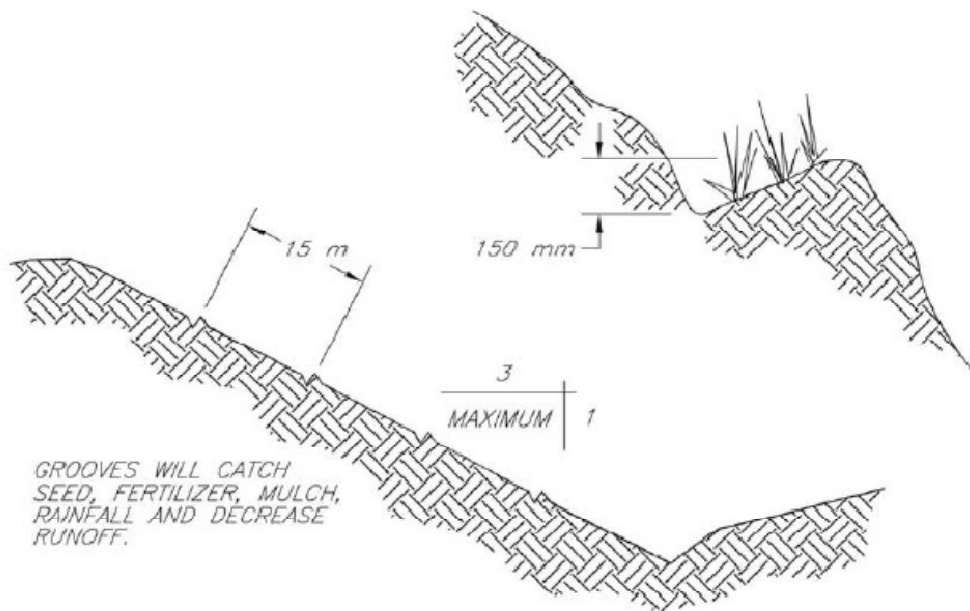
Construction Considerations

- During tracking operations, care must be taken to minimize disturbance to the soil where the equipment turns or changes direction
- Minimize the number of tracking passes to 1 to 2 times to avoid overcompaction, which can negatively impact the vegetation growth
- It is practical to track roughen a slope length of greater than 8 m by up- and downslope operation of a small bulldozer. It is important to minimize the loosening of soil caused by turning movement of the bulldozer at the end of each pass. As the erosion potential is lower for slopes of low vertical height (<3 m height and 3H:1V slope), the tracking of low height slopes is not required and not practical for a bulldozer tracking operation.



*"TRACKING" WITH MACHINERY UP
AND DOWN THE SLOPE PROVIDES
GROOVES THAT WILL CATCH SEED,
RAINFALL AND REDUCE RUNOFF.*

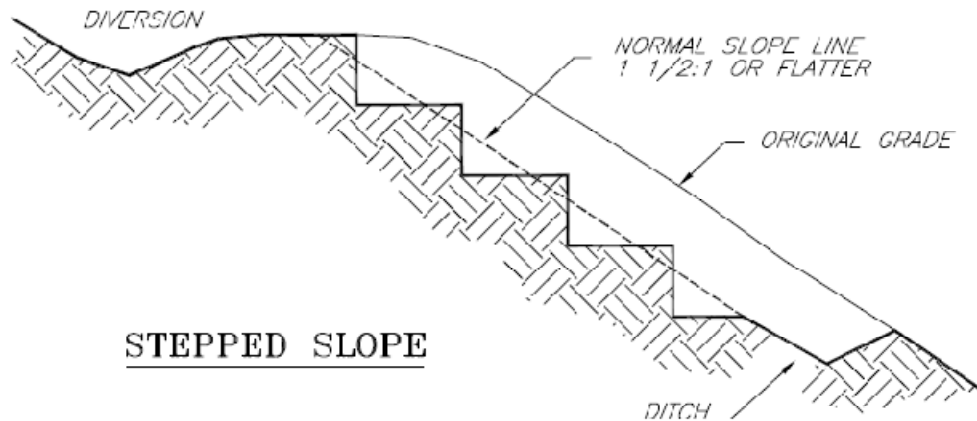
TRACKING



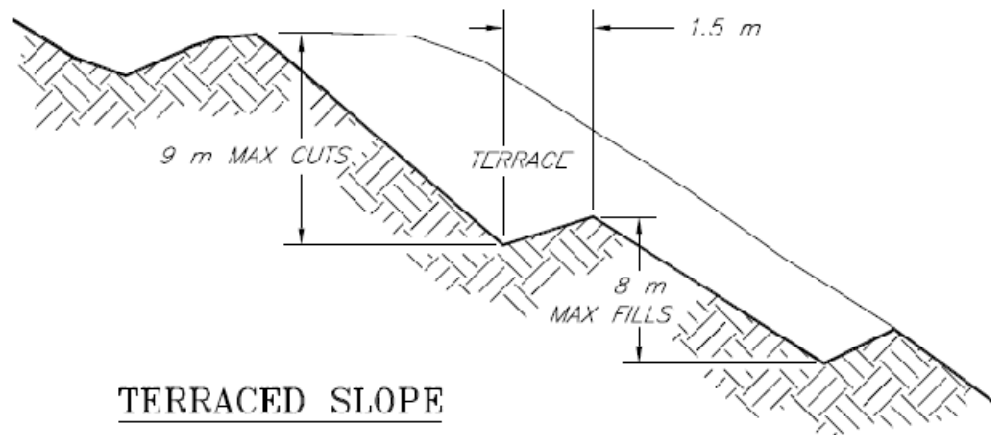
*GROOVES WILL CATCH
SEED, FERTILIZER, MULCH,
RAINFALL AND DECREASE
RUNOFF.*

CONTOUR FURROWS

**SURFACE
ROUGHENING**



STEPPED SLOPE



TERRACED SLOPE

From: Solix-Applic. Earthcare - EROSION DRAW 3.0
1994 JOHN McCULLAH

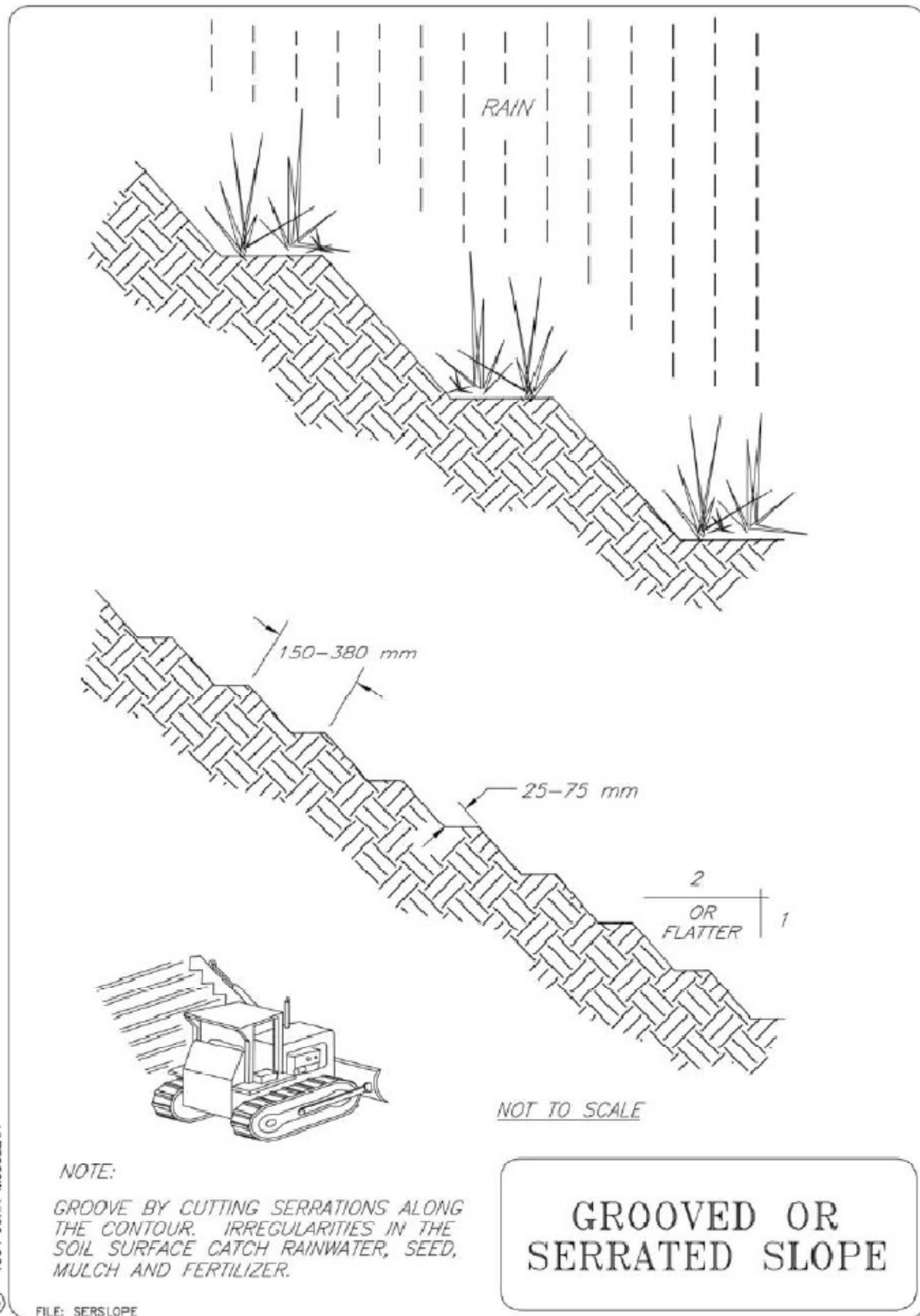


FILE: STPSLOPE

- NOTES:
1. VERTICAL CUT DISTANCE SHALL BE LESS THAN HORIZONTAL DISTANCE.
 2. VERTICAL CUT SHALL NOT EXCEED 0.6 m IN SOFT MATERIAL AND 0.9 m IN ROCKY MATERIAL.

NOT TO SCALE

**STEPPED OR
TERRACED SLOPE**



Gabions

Slope and Surface Protection

BMP 4

Description and Purpose

- Consist of rock placed inside wire baskets to protect steep or erodible slopes from sheet flow erosion
- Protects erodible stream channel banks from potentially high erosive concentrated flow velocities or high tractive forces • Can be applied to:
 - Slope and banks
 - Single gabion drop structure for ditch channel
 - Double gabion "energy dissipator" drop structure for ditch channel

Applications

- Permanent measure
- May be used on stream bank aprons and blankets where flow velocities do not exceed 6 m/s
- May be constructed to 0.5H:1V as a low height toe protection structure of slope
- May be used on slopes up to 1.5H:1V as slope protection, a grade break and sediment barrier
- Gabion mattresses are an alternative to riprap armouring of channels
- May be used to construct dikes or weirs
- Used as a drop structure (check structure) to reduce grade between structures and as sediment barrier in channels
- Used as a splash pad to reduce flow velocity and dissipate flow energy

Advantages

- Relatively maintenance free
- Long lasting and sturdy structure
- Lower thickness requirement for gabion (can be 1/2 to 1/3 riprap thickness) compared with riprap thickness for identical severe hydraulic conditions. with riprap placement
- Gabions are porous, free-draining and flexible so they are less affected by frost heaving and hydrostatic pressures
- Trap sediment and support plant growth to effect higher channel resistance to flow

Limitations

- Construction is labour intensive
- Extra costs associated with wire for mesh cages and rock fill plus geotextile fabric or sand filter layer

Construction

(Note: For guidance only. A site specific design is required from designer/engineer.)

- Prepare subgrade on mineral soil at designated gabion location
- Subexcavate trench a minimum of 0.15 m deep to 'key-in' gabion structure
- Construct gabion basket as per manufacturers recommendations
- Line interior of basket with non-woven geotextile OR a gravely sand filter layer (if required by design) along areas where the basket is in contact with soil
- Backfill basket with rock with wire bracing at 1/3 points (or 0.3 m spacings)
- Install gabion basket top
- Backfill trench and compact soil around edges of completed basket

Gabions

Slope and Surface Protection

BMP 4

Construction Considerations

- Gabions should be placed on a properly graded surface
- Non-woven geotextile should be used to prevent loss of underlying material and infiltration of fine grained particles into the gabion structure
- Rock in the baskets may be placed by hand to enhance dense packing of stones and decrease void spaces
- Construct gabions with internal wire diaphragms to maintain structural stability (shape)

Inspection and Maintenance

- Should be inspected after major storm events, especially where undermining at the toe of the basket is a concern
- Repairs should be performed immediately when required; repairs may include hand grading and/or infilling undermined area with rocky material

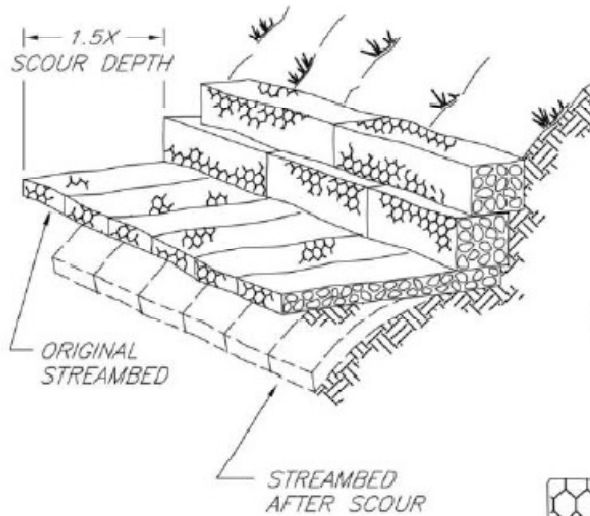
Similar Measures

- Berms/barriers
- Check dams
- Permeable/synthetic barriers
- Rock/brush barriers
- Sand/gravel bag barriers

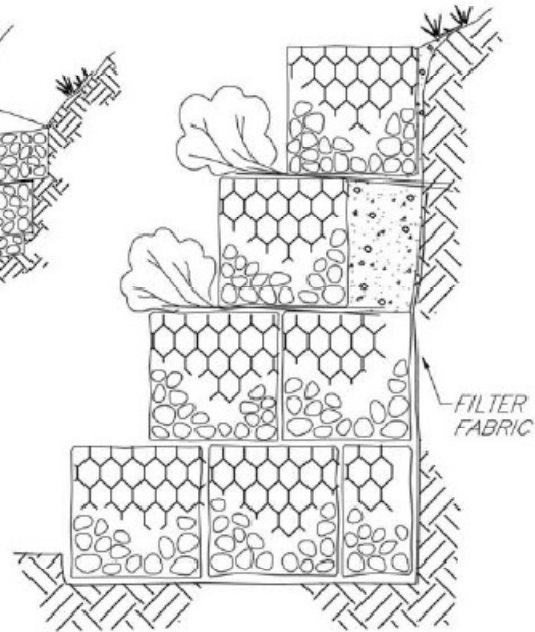
Gabions

Slope and Surface Protection

BMP 4

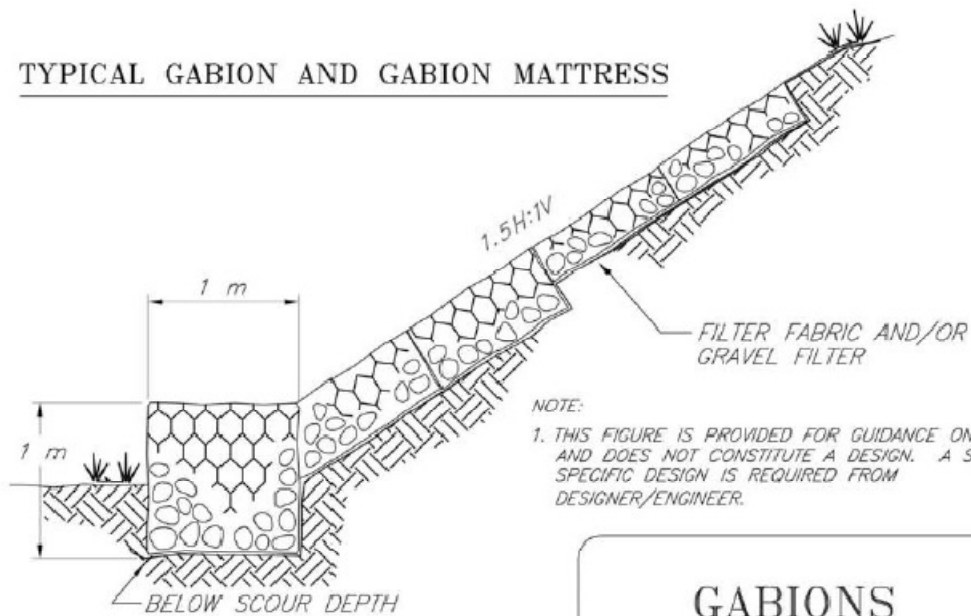


TYPICAL GABION APRON



TYPICAL VEGETATED ROCK GABION

TYPICAL GABION AND GABION MATTRESS



NOTE:

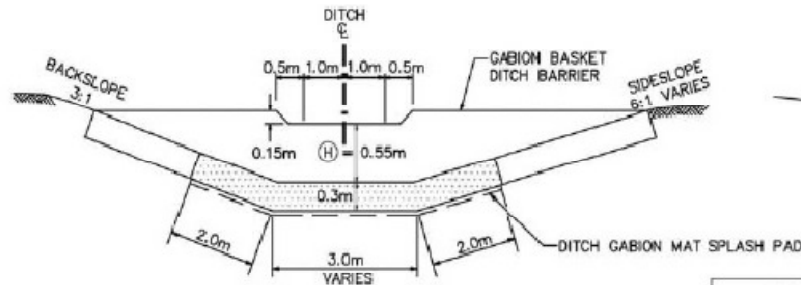
1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**GABIONS
(SLOPE AND BANK)**

Gabions

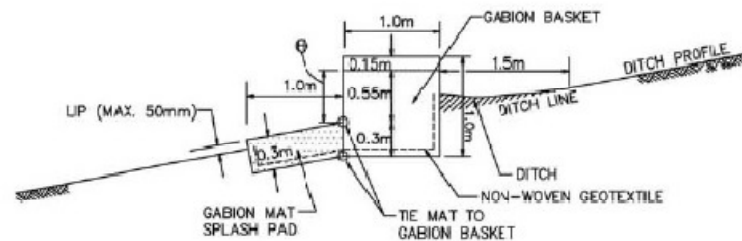
Slope and Surface Protection

BMP 4



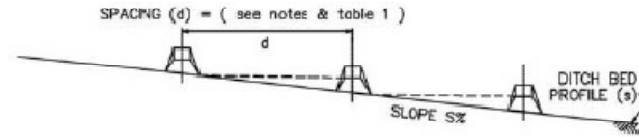
FRONT VIEW FROM DOWNSTREAM
TYPICAL DITCH CROSS-SECTION
GABION BASKET DITCH BARRIER

N.T.S.



CROSS-SECTION VIEW
"SINGLE GABION" BASKET DITCH BARRIER
& GABION MAT SPLASH PAD

N.T.S.



TYPICAL BARRIER SPACING

N.T.S.

SUGGESTED SPACING (d)		REMARKS
S (%)	(m)	
5-7	30	OPTION TO INSTALL A GRADE BREAK (s.g. WEAVE BARRIER) BETWEEN STRUCTURES.
7-8	25	A DOUBLE GABION FOLLOWS EVERY 2 SINGLE GABIONS.
>8%	≤15	DESIGN BY ENGINEER REQUIRED.

TABLE 1

NOTES:

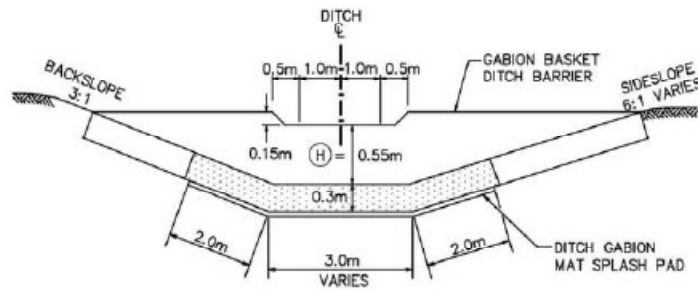
- SUITABLE FOR MEDIUM TO STEEP GRADES AND CHANNELS LEADING TO WATER COURSE $4\% < S < 10\%$.
- i) SPACING TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS. - -
ii) USE IN CONJUNCTION WITH DOUBLE GABIONS OR OTHER BARRIER STRUCTURES.
- SOIL COVERING BETWEEN STRUCTURES SUGGESTED FOR STEEP GRADE SOIL DITCH.
- THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**GABIONS
SINGLE GABION
DROP STRUCTURE FOR
DITCH CHANNEL**

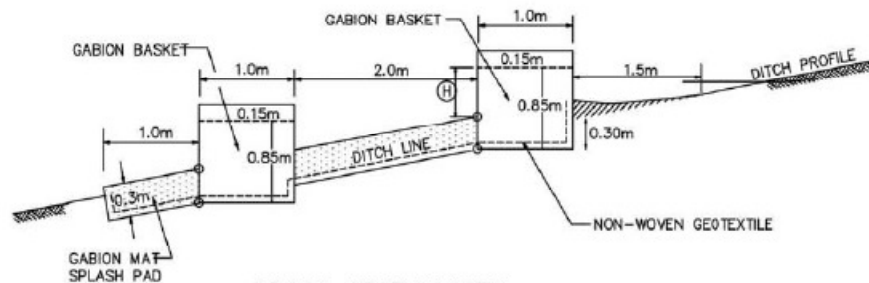
Gabions

Slope and Surface Protection

BMP 4

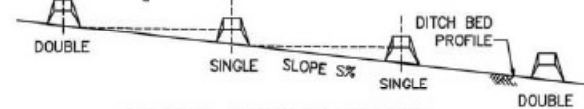


FRONT VIEW FROM DOWNSTREAM
TYPICAL DITCH CROSS-SECTION
GABION BASKET DITCH BARRIER
N.T.S.



CROSS-SECTION VIEW
"DOUBLE GABION" ENERGY DISSIPATION GABION STRUCTURE
(TWO SINGLE GABIONS COMBINED)
N.T.S.

SPACING (d) = (see table 1 and notes)



TYPICAL BARRIER SPACING
N.T.S.

SUGGESTED SPACING (d)		REMARKS
S (%)	(m)	
6-8	25	INTER-SPACED WITH 2 SINGLE GABIONS BETWEEN STRUCTURES *SEE NOTES
	35*	
>8%	≤15	DESIGN BY ENGINEER REQUIRED

TABLE 1

NOTES:

- SUITABLE FOR STEEP GRADES (6% < S < 12%) AND CHANNELS LEADING TO WATER COURSE
- i) SPACING (d) TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
ii) USE IN CONJUNCTION WITH SINGLE GABION AND/OR OTHER GRADE BREAK STRUCTURES.
- SUGGESTED TWO SINGLE GABIONS AT INTERVAL BETWEEN DOUBLE GABIONS.
- SOIL COVERING BETWEEN STRUCTURES SUGGESTED FOR STEEP GRADE SOIL DITCH.
- IF $d^* = 35$ m at 7 to 8% GRADE
 - GRADE BREAK (s.a. PERMEABLE WEAVE BARRIER) SHOULD BE PLACED BETWEEN STRUCTURES.
 - LONG SPACING ALLOWABLE WHEN HYDRAULIC CONDITIONS NOT SEVERE.
- THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

GABIONS
DOUBLE GABION
"ENERGY DISSIPATOR"
DROP STRUCTURE
FOR DITCH CHANNEL

Fibber Rolls and Wattles <i>Slope and Surface Protection</i>	BMP 5
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Description and Purpose

- Straw roll consists of bundled straw (or natural fibre) wrapped in photo-degradable openweave plastic netting staked into the soil along slope contours as a grade break to reduce erosion potential
- Wattles consist of bundled live fascine to stake into the soil along slope contours
- Fibre rolls are installed across slope contours as a grade break to reduce erosion potential by reducing overland flow velocities
- Normally live stake can be installed to anchor the Fibre Rolls and Wattles to provide deep root vegetation with potential favourable moisture retention provided by Fibre Roll
- Fibre rolls and wattles also capture sediment, organic matter, and seeds carried by runoff

Applications

- Temporary measure
- May be used on slopes stable enough to support vegetation (steep, confined, slopes and channel banks with gradients greater than 1H:1V may have low success potential)
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used along long slopes as a grade break to shorten slope length between line of fibre rolls at different contour elevations
- May be used as grade breaks, where slopes transition from flatter to steep gradients
- May be used on lake shores as wave break to assist in revegetation and stabilization of banks
- Can be used in conjunction with live staking as bioengineering measure

Advantages

- Grade break measure to lower sheet and rill erosion potential
- Can be used on slopes too steep for silt fences or straw bales sediment barriers
- In time, plastic netting will degrade due to the sunlight and straw will degrade and be incorporated into the soil
- Primary purpose is erosion control, however fibre rolls do provide some sediment control

Limitations

- Designed for low sheet flow velocities
- Designed for short slopes with a maximum gradient of 1H:1V
- May be labour intensive to install
- Few precedents as this measure is generally not used on AT construction projects
- Straw rolls have short life span due to natural degradation
 - Usually only functional for two seasons
- Susceptible to undermining and failure if not properly keyed into the soil
- Labour intensive maintenance may be required to ensure rolls are in continuous contact with the soil, especially when used on steep slopes or sandy soils

Construction (Note: For guidance only. A site specific design is required from the designer/engineer)

- Prepare slope face and remove large rocks or other deleterious materials
- Excavate small trenches a minimum of 0.15 m deep and 0.15 m wide across the width of the slope, perpendicular to slope direction, starting at the toe of the slope and working upwards towards crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place fibre rolls into trench ensuring continuous contact between fibre roll and soil surface
- Butt-joint adjacent fibre roll segments tightly against one another
- Use a metal bar to make pilot hole through middle of the fibre roll a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1 m apart

Fibber Rolls and Wattles <i>Slope and Surface Protection</i>	BMP 5
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- • Secure fibre roll to soil using wooden stake or other appropriate anchor; live stake may be used as alternate anchor
- • Place soil excavated from trench on upslope side of fibre roll and compact to minimize undermining of fibre roll by runoff
- • Seed the soil along the upslope and downslope sides of the fibre roll to promote vegetation growth

Construction Considerations

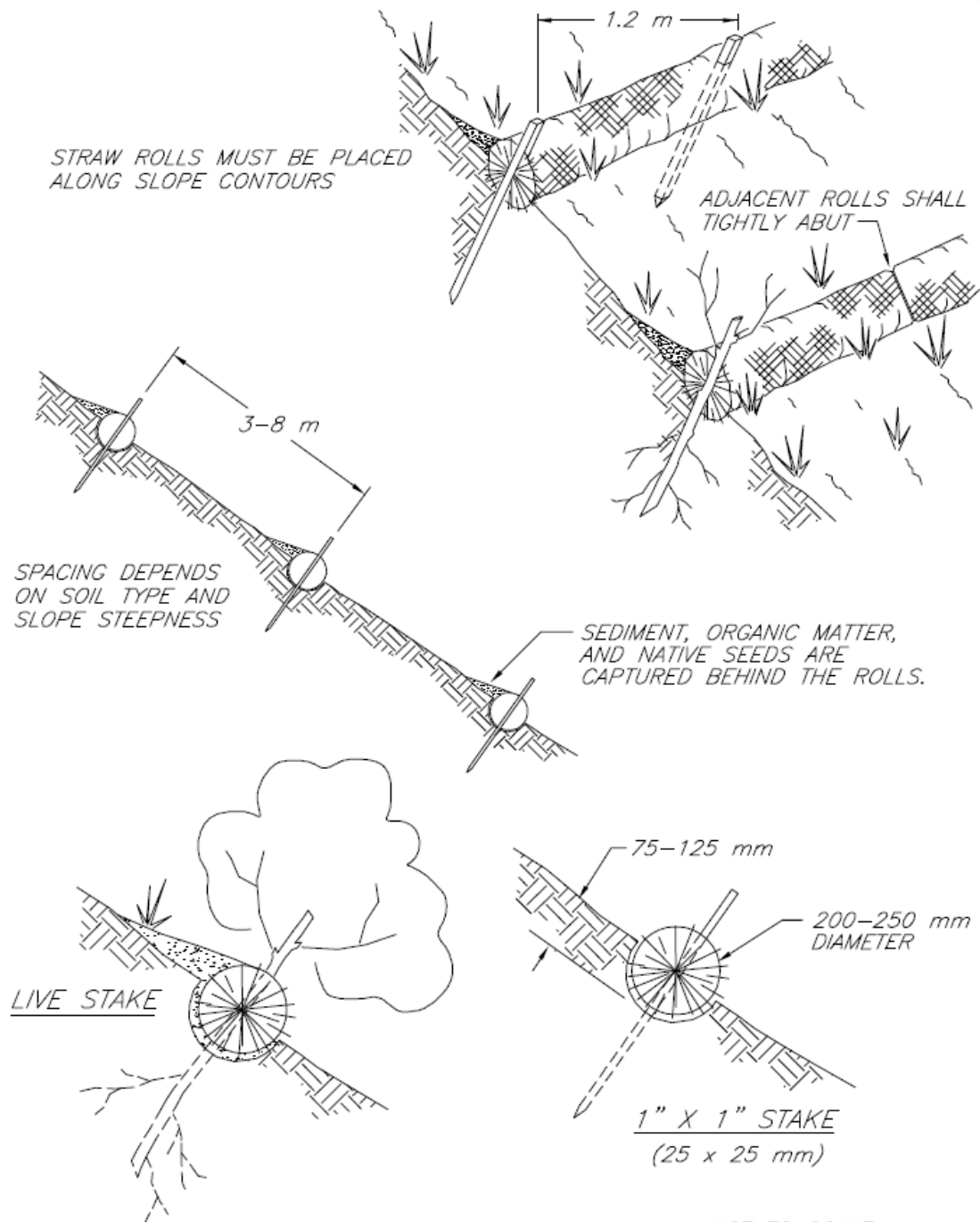
- Use live stakes in place of wooden stakes
- If the slope soil is loose and uncompacted, excavate trench to a minimum depth of 2/3 of the diameter of the fibre roll
- For steep slopes, additional anchors placed on the downslope side of the fibre roll may be required

Inspection and Maintenance

- Inspect structures at biweekly intervals or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rutting should be repaired immediately
- Additional stormwater control measures should be considered for rilling areas damaged by runoff

Similar Measures

Synthetic permeable barriers

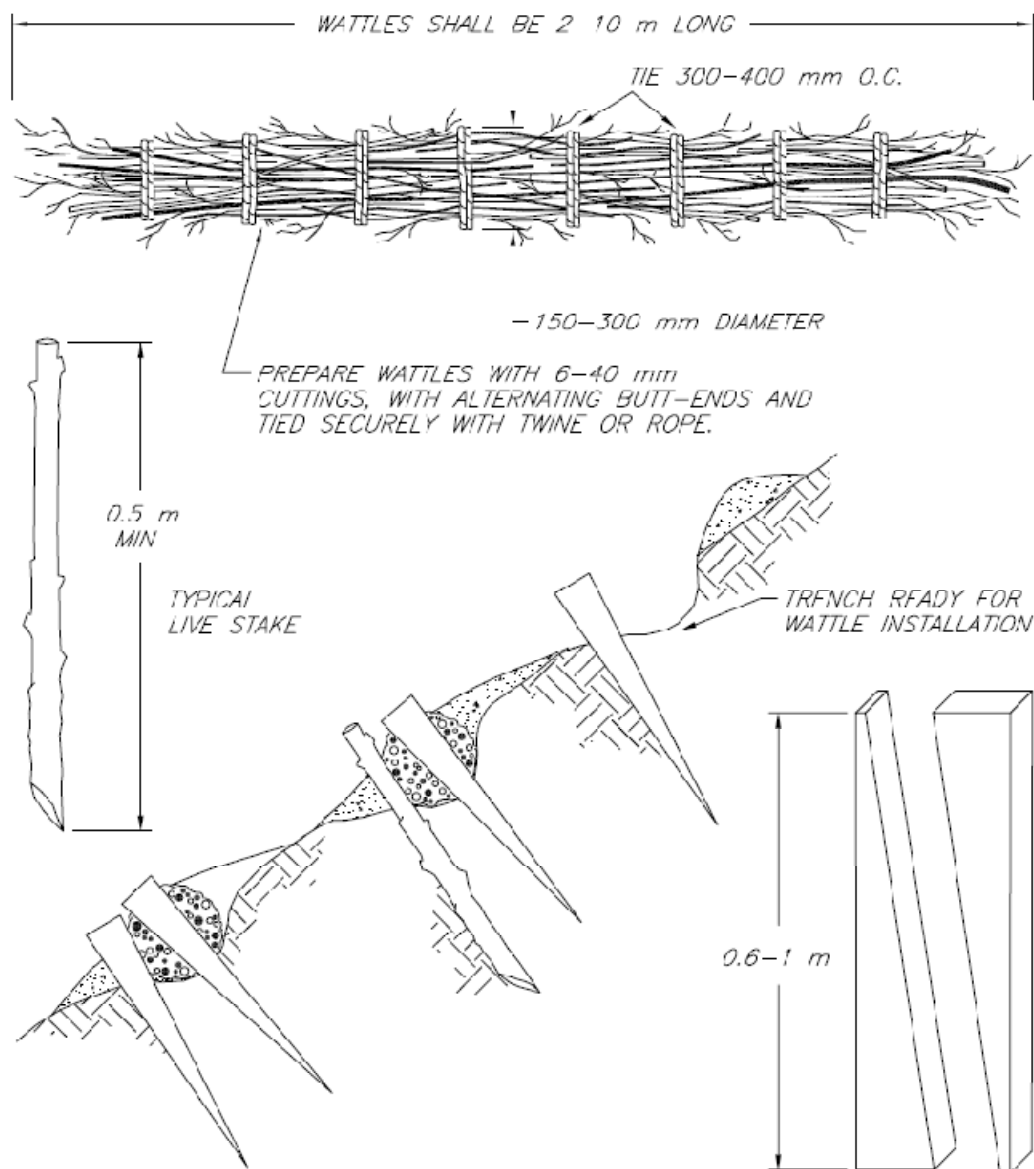


NOTE:

1. STRAW ROLL INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE ROLL IN A TRENCH, 75-125 mm DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND ROLL.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

**STRAW
ROLLS**



NOTES:

1. HARVEST AND INSTALL WATTLES DURING DORMANT SEASON.
2. INSTALL WATTLES ON SLOPE CONTOURS.
3. ALL WORK PROCEEDS FROM THE BOTTOM OF THE SLOPE TO THE TOP.
4. FILL OR PARTIALLY COVER WATTLE WITH SOIL FROM SLOPE OR TRENCH ABOVE.
5. COMPACT AND WORK SOIL INTO COMPLETED WATTLE'S.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

TYPICAL CONSTRUCTION STAKE
SAW 2X4 (100X50 mm) LUMBER
ON DIAGONAL

NOT TO SCALE

**WATTLE
(LIVE FASCINE)**

Soil Tackifiers (Chemical Stabilization) <i>Slope and Surface Protection</i>	BMP 6
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Description and Purpose

- Chemical substances that are sprayed onto disturbed soils to effect a change of soil properties, generally by aggregating finer soil particles
- Aggregated finer soil particles are less susceptible to erosion and reduce erosion potential of exposed slopes

Applications

- Temporary measure
- May be used in place of, or in conjunction with, mulch materials to act as both a soil stabilizer and mulch binding agent
- May be used for exposed soils not subject to traffic during the temporary establishment of a seedbed
- May be used to provide temporary erosion protection before revegetation is started
- May be used in areas where success of vegetation as a soil stabilizer is very difficult
- Primarily used on dry, highly permeable soils or in soils already in place which are subjected to sheet flow rather than concentrated flows
- May be used in wind erosion prone areas as temporary protection

Advantages

- Chemical stabilizers increase cohesion of soil surface which helps development of permanent vegetative cover by reducing erosion and reducing evaporation of soil moisture
- Efficiently sprayed over large areas of exposed soils

Limitations

- Site must be accessible to hydroseeding-hydromulching equipment
 - Usually mounted on trucks
 - Maximum hose range of approximately 150 m
- May require additional specialized equipment not commonly used during construction activities
- Increased longevity if chemical stabilizer application rate is increased, however, increased application rates may prevent seeds from germinating
- Crust-forming chemical stabilizers (such as bitumen) may crack during freeze-thaw cycles

Construction *(Note: For guidance only. A site specific design is required from designer/engineer.)*

- Prepare slope face and remove large rocks or other deleterious materials
- Place topsoil and seed (if required)
- Spray on chemical stabilization according to suppliers recommended application rate

Construction Considerations

Chemical Soil Stabilizers

- Alginate - Paste-like emulsion or granulate produced from sea algae and consisting largely of natural carbohydrates with associated minerals added
- Aquatain - Water dispersible, non-toxic
- Asphalt Sprays - Available as an asphalt emulsion or as a liquid asphalt
- Bitumen - Thick-flowing undilutable emulsion or a cold emulsion, 50% dilutable with water
- DCA - 70 - Water dispersible, non-toxic, non-phytotoxic
- Hydrosilicates Methylcellulose - Gel-like elastic film in a powder form or as a water based emulsion
- Plastic Emulsion - Usually a liquid which can be diluted with water producing a thin film to cover the soil surface
- Polyvinyl Alcohol - An emulsion with water

Inspection and Maintenance

Soil Tackifiers (Chemical Stabilization)

Slope and Surface Protection

BMP 6

- Inspect treated areas at biweekly intervals or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Additional stormwater control measures should be considered for severe rilling areas damaged by runoff
- Period of effectiveness lasts from a few weeks to a few months, depending on application rate
 - Repetitive application will prolong effectiveness

Similar Measures

- Hydroseeding-hydromulching
- Rolled erosion control products (RECP)

Description and Purpose

- Permeable fabric barriers installed vertically on support posts along contours to collect and/or filter sediment laden sheet flow runoff
- Causes water to pond allowing sediment to settle out as water filters through fabric
- Decreases flow velocity in channels with low to moderate flows ($< 0.03 \text{ m}^3/\text{s}$)
- Entraps and minimizes coarse sediment from sheet flow or overland flow from entering waterbodies
- Perimeter control for sediment transport and deposition

Applications

- Temporary measure
- Used at bottom of cut or fill slopes to collect sediment laden runoff
- Used in swales or ditches with low flow velocity and flow less than $0.03 \text{ m}^3/\text{s}$
- Used along streams (or channels) banks
- Used around stockpiles
- Midslope grade-break (using "J-hook" or "smile" pattern to effect ponding, filtering and sedimentation)

Advantages

- Low permeability silt fences have high filtering capabilities for fine sand to coarse silt
- Filter fence more effective than straw bales at filtering out sediment

Limitations

- Applicable for sheet flow, normally cannot handle concentrated channel flow volumes
- May fail under high runoff events
- Limit to locations suitable for temporary ponding of sediment laden runoff
- Not to be used in swales or ditches with flow greater than $0.03 \text{ m}^3/\text{s}$
- Low permeability silt fences may not be strong enough to support weight of water retained behind it and may require reinforcement (i.e. wire mesh and stronger support post)
- Sediment build up needs to be removed at 1/2 height and on a regular basis
- Damage to fence may occur during sediment removal
- Useable life of approximately one year dependent on maintenance and sediment requirement

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- Two methods of installation are commonly used
 - Trench method
 - Mechanical (slicing) installation method (e.g. Tommy Silt Fence Machine or equivalent)
- Trench Method
 - Select location of silt fence (usually along contours)
 - Drive support posts a minimum of 0.3 (preferable 0.6 m) into ground, spaced a maximum of 2 m apart
 - Excavate trench approximately 0.15 m deep by 0.15 m wide for entire length of fence along upstream side of posts
 - Attach the wire mesh or snow fencing, if used as reinforcement to fence fabric, to
- upstream side of posts with staples
 - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts
 - Backfill and compact soil in trench, being careful not to damage fence
- • Mechanical Installation Method
 - Select location of silt fence (usually along contours)
 - Use mechanical installation machine to embed the fabric a minimum of 0.15 m into the ground. One mechanical installation method is by slicing (with special equipment) the
- geotextile fabric to embed into the ground without excavation and backfill. Minor
- disturbance of ground if affected and only tamping of ground is required for compaction.
 - Drive support posts a minimum of 0.3 (preferable 0.6 m) into ground, spaced a maximum of 2 m apart
 - Attach the wire mesh or snow fencing, if used as reinforcement to silt fence fabric, to
- upstream side of posts with staples
 - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts

Construction Considerations

- Site Selection
 - Size of drainage area should be no greater than 0.1 ha per 30 m length of silt fence
 - Maximum flow path length above silt fence should be no greater than 30 m
 - Maximum slope gradient above the silt fence should be no greater than 2H:1V
 - For use in swales, gradient should be less than 2% and drainage area less than 0.8 ha
- Fence should be placed on contour to produce proper ponding
- Fence should be placed far enough away from toe of slope to provide adequate ponding area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of fence should be angled upslope to collect runoff
- Fence should not extend more than 0.6 m above grade
- Posts can be wood or metal material dependent on design and ground conditions
- Posts should be placed on downstream side of fence
- Posts should be driven at least 0.3 m (preferable 0.6 m) into the ground
- Posts should not be spaced greater than 2 m apart
- Wire mesh or standard snow fencing may be placed between the posts and filter fabric to provide additional strength and support reinforcement
- Filter fabric should be cut from a continuous roll to avoid joints (if joints are necessary, the wrapping of fabric around the fence post and a minimum overlap of 0.2 m with staples should be used to attach the fabric to the post)
- Fence (and wire mesh or snow fence, if used) should be attached to posts with heavy duty staples, tie wires, or hog rings
- Fence (and wire mesh or snow fence, if used) should be dug into a trench at least 0.15 m deep to prevent undercutting of fence by runoff
- Trench backfill should be compacted
- Long runs of silt fence are more prone to failure than short runs
 - Maximum length of each section of silt fence should be 40 m
 - Silt fence should be installed in 'J' hook or 'smile' configuration, with maximum length of 40 m, along contours allowing an escape path for ponded water (minimizes overtopping of silt fence structure)

Inspection and Maintenance

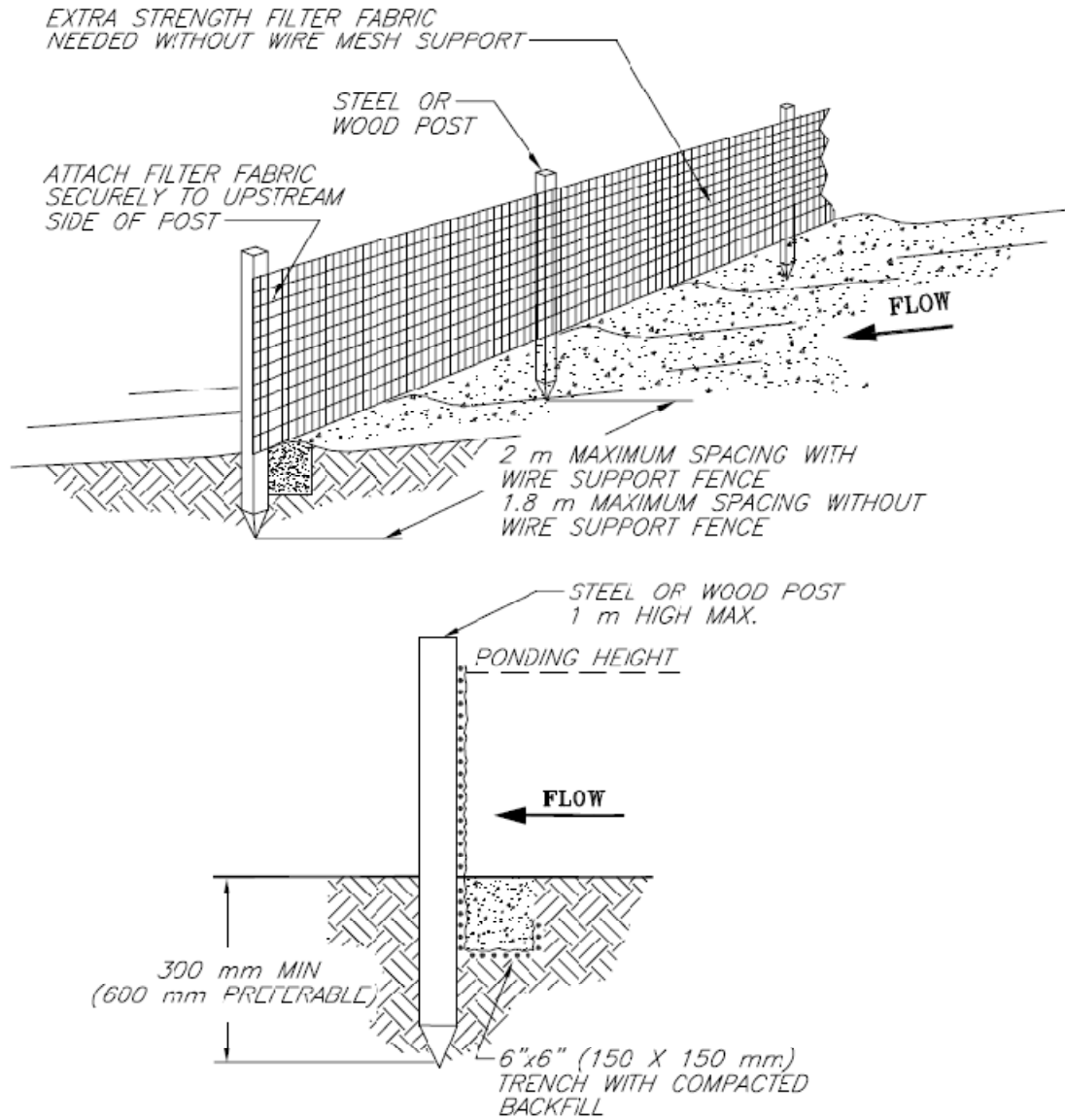
- Inspections should occur twice per week and after significant storm events (1:2 year storm event and/or +40 mm rainfall over 24 hours duration)
- Repair undercut fences and repair or replace split, torn, slumping or weathered fabric immediately
- Sediment build up should be removed once it accumulates to a depth of 0.2 m or at ½ height of fence
- Remove fence after vegetation is established
- Deactivate fabric by cutting-off top portion of fabric above ground; bottom trenched-in portion of fence fabric can be left in-ground thus minimizing ground disturbance

Similar Measures

- Straw Bales
- Rock Barrier
- Check Dams
- Permeable/Synthetic Barriers

Design Considerations

- For a silt fence system to work as a whole, the following factors should be considered:
 - quantity – adequate number and frequency of fence for efficient ponding and sedimentation
 - installation – workmanship
 - compaction – backfill and trenching of fabric
 - support – posts adequately embedded and of strong material and close spacings
 - attachment – secure fabric to post
- Install silt fences in a 'J' hook or 'smile' configuration to allow efficient ponding and
 - sedimentation as well as escape route for excess runoff along the ends
 - Minimizes overtopping of structure



TRENCH METHOD OPTION DETAIL

NOTES:

1. SILT FENCE SHALL BE PLACED ON SLOPE CONTOURS TO MAXIMIZE PONDING EFFICIENCY.
2. INSPECT AND REPAIR FENCE AFTER EACH STORM EVENT (1:2 YEAR STORM AND/OR +40 mm RAINFALL OVER 24 HOUR DURATION) AND REMOVE SEDIMENT WHEN ACCUMULATED SILT REACHES 1/2 FENCE HEIGHT OR 225 mm MAXIMUM SUGGESTED STORAGE HEIGHT.
3. REMOVED SEDIMENT SHALL BE DEPOSITED TO AN AREA WILL NOT CONTRIBUTE SEDIMENT OFF-SITE.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

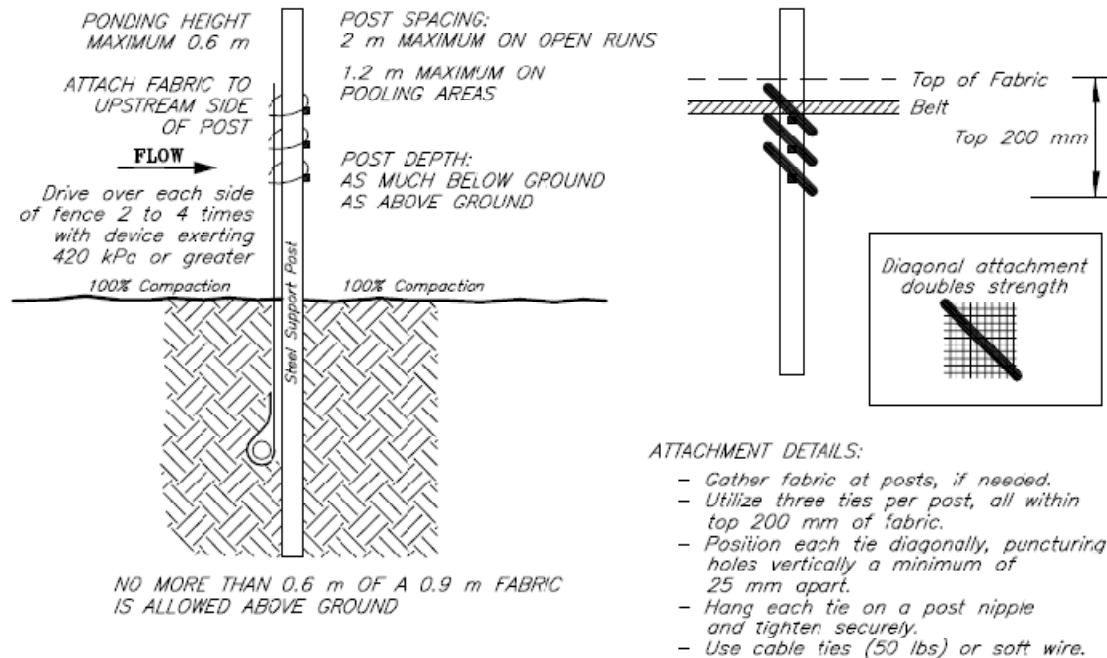
NOT TO SCALE

SILT FENCE
(TRENCH METHOD OPTION)

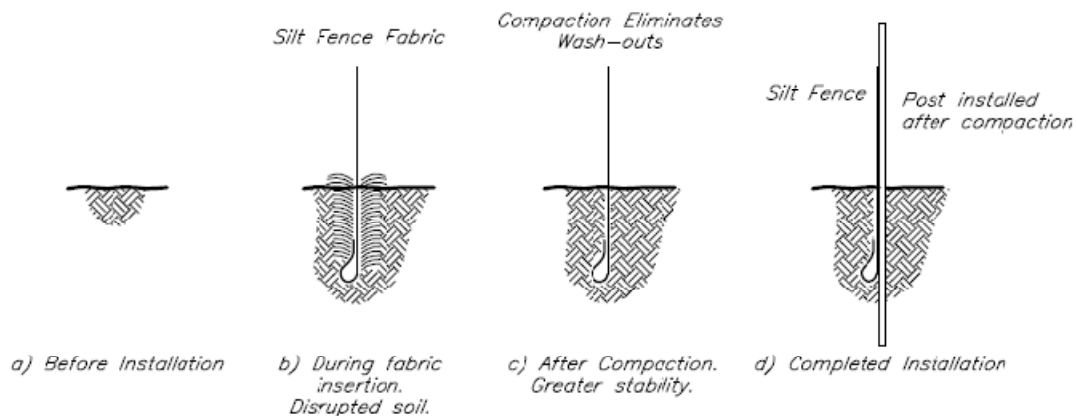
FILE: SILTFENC

Silt Fence (Filter Fence) Sediment Control

BMP 7



THE MECHANICAL (SLICING) METHOD



THE MECHANICAL (SLICING) METHOD INSTALLATION SEQUENCE

NOTES:

NOT TO SCALE

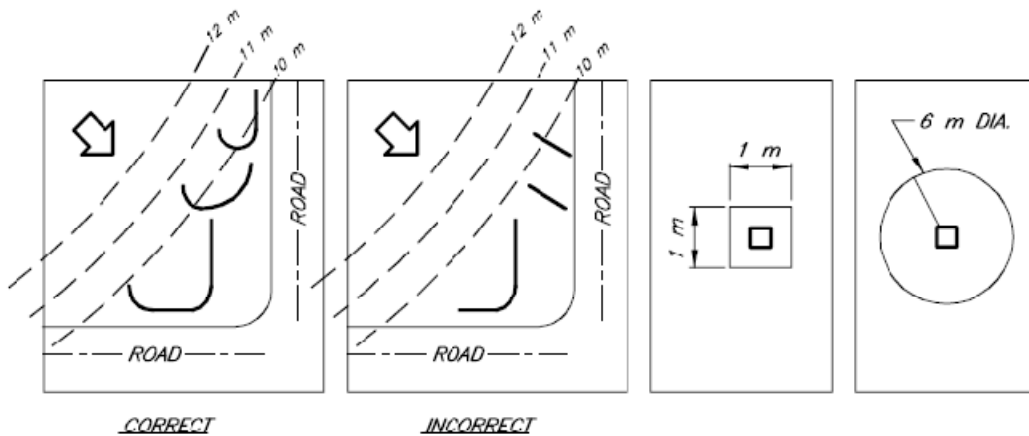
1. INSTALLATION MACHINE MUST ALLOW CONTINUOUS SLICING AND EMBEDMENT OF GEOTEXTILE INTO GROUND WITH MINOR GROUND DISTURBANCE.
2. INSTALLATION MACHINE TYPES WILL VARY WITH MANUFACTURER.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: CARPENTER T. 2000

SILT FENCE
(MECHANICAL METHOD OPTION)

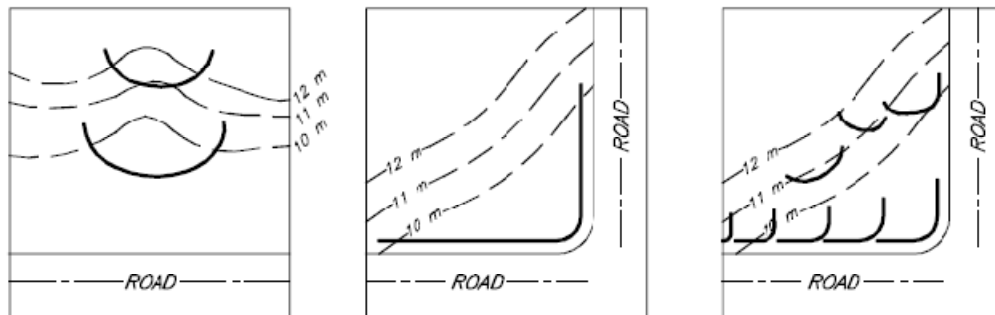
Silt Fence (Filter Fence) Sediment Control

BMP 7



"J" CONFIGURATION

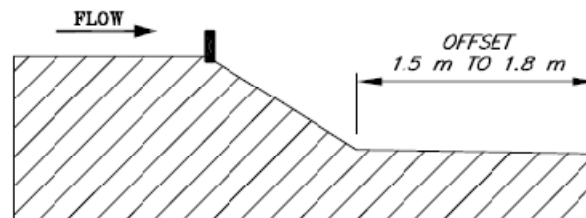
SILT FENCE BARRIER
AT STORM INLET



"SMILE"
CONFIGURATION

AVOID LONG
INSTALLATION

COMBINATION OF "SMILE"
AND "J" CONFIGURATIONS



LOCATION AT TOP AND BOTTOM OF SLOPE

NOT TO SCALE

NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: CARPENTER T. 2000

**SILT FENCE
(CONFIGURATION PLAN)**

Description and Purpose

- Low height dam enclosure for impoundment of sediment laden storm water, sedimentation and release of treated runoff
- Used to trap sediment laden run off and promote settlement of sediment prior release
- Constructed by excavating a pond or building embankments above the original ground surface
- Sediment traps and basins can be divided by size of pond impoundment enclosure
 - Basin (Type I) for pond area $\geq 500 \text{ m}^2$
 - Trap (Type II) for pond area $\leq 500 \text{ m}^2$

Applications

- Temporary (for construction period) or permanent measure
- Used at terminal or selected intermediate points of concentrated runoff for impoundment of runoff and sedimentation of silt prior to release of treated runoff
- Used as a sediment control measure at outlets from construction sites where runoff may enter watercourses, storm drains, or other sensitive areas
- Used where there is a need to impound a significant amount of sediment from significant areas of land disturbance
- Removal of small diameter particles may require use of flocculants. This should be done with caution to prevent adverse effects on aquatic life
- Sediment basins (Type I) used for disturbed drainage areas greater than 2.0 ha
- Sediment traps (Type II) used for disturbed drainage areas of 2.0 ha or less
- Where practical, contributing drainage areas should be subdivided into smaller areas and multiple sedimentation impoundment installed

Advantages

- High capacity of runoff impoundment and more efficient means of sedimentation necessary along perimeters of construction sites with high risk sensitive environmental areas and watercourses
- Sediment can be cleaned out easily
- Robust
- Can be deactivated easily by breaching the enclosure dyke

Limitations

- Requires specialized design by qualified personnel
- Sediment traps and basins do not remove 100% of the sediment; net efficiency for sedimentation of silt may be around 50% dependent on design
- Anticipated service life of 3 years or longer due to possible clogging of outlets in the long-term
- Sedimentation traps and basins with a riser outlet should have an auxiliary spillway with adequate erosion protection to permit overflow in the event that the riser pipe outlet clogs during a storm event
- For drainage areas greater than 40 ha, multiple basins may be required
- Efficiency of sedimentation is very dependent on surface area; sediment basins require large surface areas to permit settling of sediment
- Fences and signage may be required to reduce danger to the public
- May provide breeding habitat for mosquitoes and other pests
- Sediment traps only remove medium and large diameter silt particles and upstream erosion or sediment control measures are required to reduce the amount of sediment laden to the runoff at downstream sensitive areas
- Periodic removal of accumulated sediment is required

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- The consequences of failure for any water retaining structure will determine the level of effort in the design and construction phases. The construction guidelines
- presented herein are minimum requirements. A geotechnical engineer should design water retaining structures if warranted by the consequences of failure

- All footprint areas for embankment dykes should be stripped of vegetation, topsoil, and roots to expose a mineral soil subgrade
- Embankment fill material should be clean mineral soil with sufficient moisture to allow proper compaction
- Fill should be placed in lifts not exceeding 150 mm in compacted thickness and should be compacted to a minimum of 95% Standard Proctor maximum dry density (SPD)
- The main outlet structure should be installed at farthest possible point from inlet
 - The outlet should be placed on firm, smooth ground and should be backfilled to 95% SPD
 - Proper inlet and outlet protection should be installed to protect from scour
 - The outlet pipe should consist of corrugated steel pipe to protect against pinching and blockage
- The embankment should be topsoiled, seeded or protected with gravel or riprap immediately after construction
- Construct an emergency spillway to convey flows not carried by the principal outlet
 - The emergency spillway should consist of an open channel (earth or vegetated) over native undisturbed soil (not fill)
 - If the spillway is elevated, it should be constructed of rip rap
 - The spillway crest should be depressed at least 0.15 m below embankment

Construction Considerations

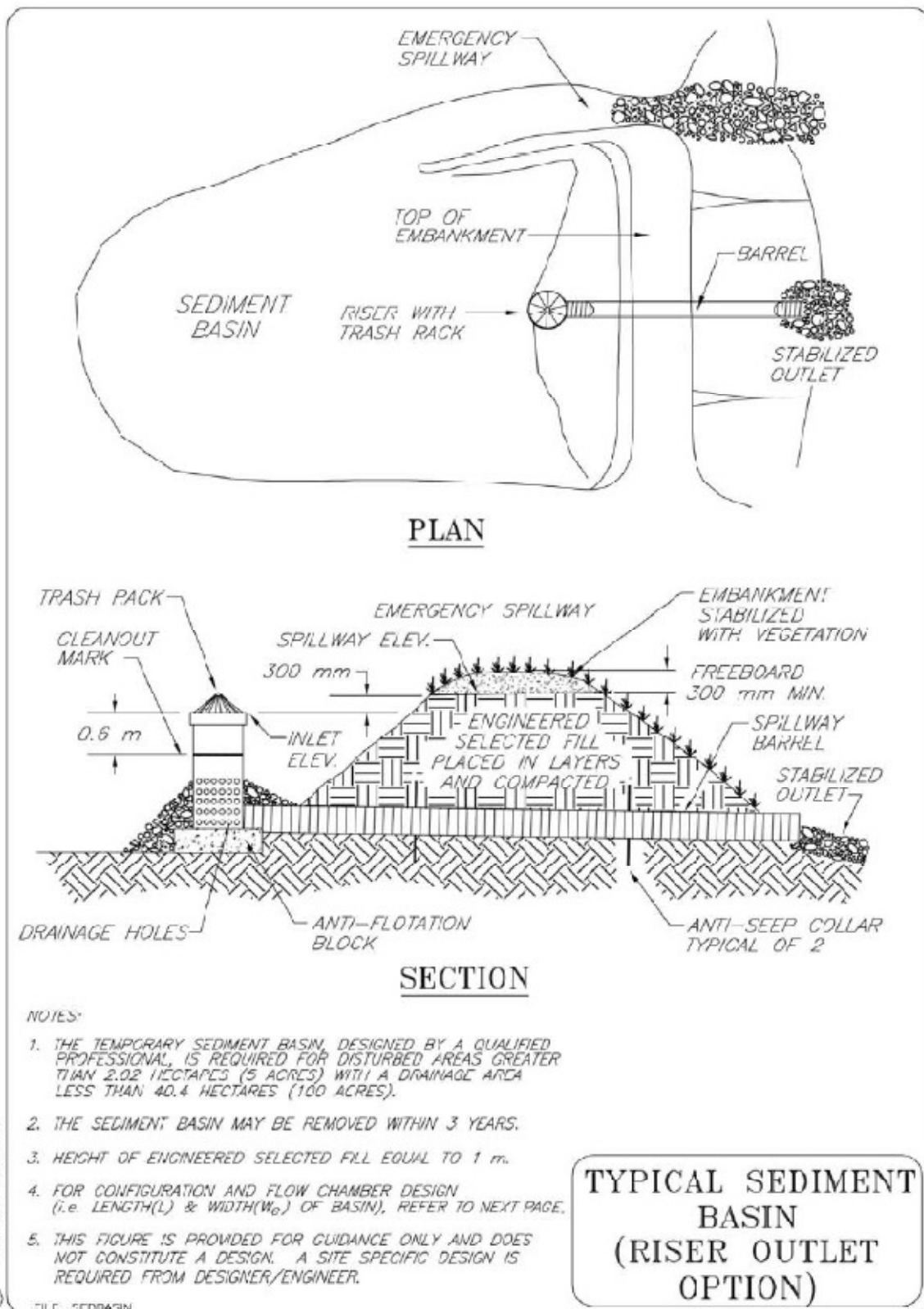
- It is preferable to strip to mineral soil only along the footprint area required for dyke construction; the pond floor centre area can be left cleared but unstripped
- The pond can be constructed by excavating, constructing embankments, or a combination of the two methods
- Baffles should be provided to prevent short-circuiting of flow from inlet to outlet. The optimum ratio of flow length to flow width is 5:1
- Construct sediment ponds and basins at the construction site perimeter prior to wet season and construction activities
- Sediment pond/basin bottom should be flat or gently sloping towards outlet
- Dyke slopes should not be steeper than 2H:1V and should be well-compacted
- Basins should be located where:
 - Low embankment can be constructed across a swale or low natural terrain
 - It is accessible for maintenance work, including sediment removal

Inspection and Maintenance

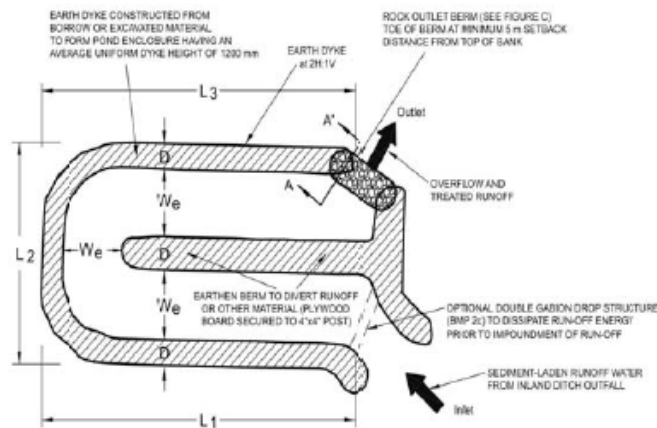
- Regular inspection is required to identify seepage, structural soundness, outlet damage or obstruction and amount of sediment accumulation
- Inspections should be performed weekly and after significant storm events (1:2 yr storm and/or 40 mm rainfall in 24 hours)
- Sediment should be removed upon reaching 1/2 height of the containment berm or within 0.4 m of crest of embankment
- Sediment traps may be deactivated or removed after vegetation of previously disturbed upstream areas has been established

Design Considerations

- The design can use a riser outlet option or a permeable rock berm outlet option. The permeable rock berm outlet option is recommended for most Applications
- Minimum particle size for rock rip rap shall be 200 mm
- If the design of a riser outlet is utilized
 - Main outlet pipe shall be fabricated from corrugated steel pipe conforming to
- CSA standard CAN 5-G401-M81 or the latest revision thereof
 - Outlet pipe shall consist of a horizontal pipe welded to a similar vertical riser at a 45° mitre joint
- Close to the base of the riser pipe, a 100 mm diameter hole shall be fabricated and a mesh with 12 mm square openings tack welded over the hole as a screen
 - A similar hole shall be provided along the riser pipe immediately above the elevation of the maximum sediment buildup (usually 0.4 m below crest of embankment)



From: Soils-Applied Earthcare - EROSION DRAW 3.0
1994 JO-HH McCULLAH



NOTES:

1. CONTRIBUTING RUFF AREA CAN BE LARGER THAN 2.0 ha BUT LESS THAN 40.0 ha
2. EFFECTIVENESS APPROPRIATE FOR REMOVING MEDIUM TO COARSE SILT PARTICLES SUSPENDED IN RUNOFF
3. FLOW PATH $L = L_1 + L_2$ 3' FLOW WIDTH $W \geq 5$ ft MINIMUM
4. PROVIDE 1 to 2 in (1 to 2% GRADE) ELEVATION DROP BETWEEN INLET AND OUTLET GRACES
5. SHAPE OF POND TO CONFORM TO TOPOGRAPHY WITH OUTLET AT MINIMUM 5 ft FROM TOP OF BANK
6. CONSTRUCTION TO ENSURE SANDS AND SUFFLES ARE TO CHANNEL WATER INTO THE PROPOSED SEDIMENTATION POND.

Figure A Type 1 Sedimentation Pond Containment Structure (Sediment Basin)

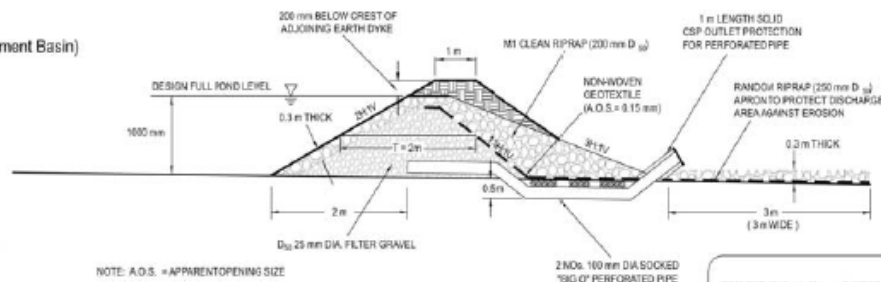
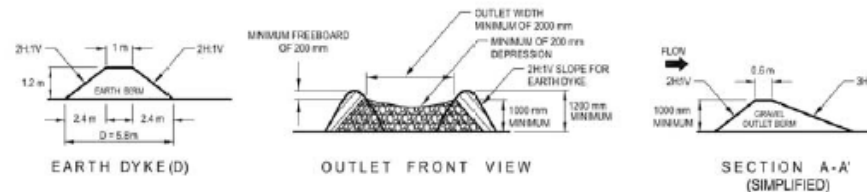


Figure C Section A-A' - Details for Sedimentation Pond
(Permeable Structure with Rock Filter Barrier and Perforated Pipe)

TYPICAL SEDIMENT BASIN
(PERMEABLE ROCK BERM
OUTLET OPTION)

NOTES:

1. DEACTIVATED WITHIN 3 YEARS AFTER SATISFACTORY FULL PVEGETATION OF THE DISTURBED AREA OF POTENTIAL EROSION SOURCES UPSTREAM.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: 1) FIELD (2001) FOR STRUCTURE PLAN
2) EBA FOR OTHER DESIGN DETAILS

Source: Ontario BMP 35-6

Description and Purpose

- A temporary dam constructed of earth, sheet piling or other material to enclose a work area and permit the removal of water
- Portable fabric cofferdams may be considered for use in Ontario
- To isolate equipment, materials and operations

Applications

- Work areas that encroach into a watercourse, lake, or wetland
- Areas where the coffer dam will not hinder passage of fish and brats

Advantages

- Permits work to be carried out in the dry
- Allows boat and fish passage
- Does not unduly affect flow in the stream

Limitations

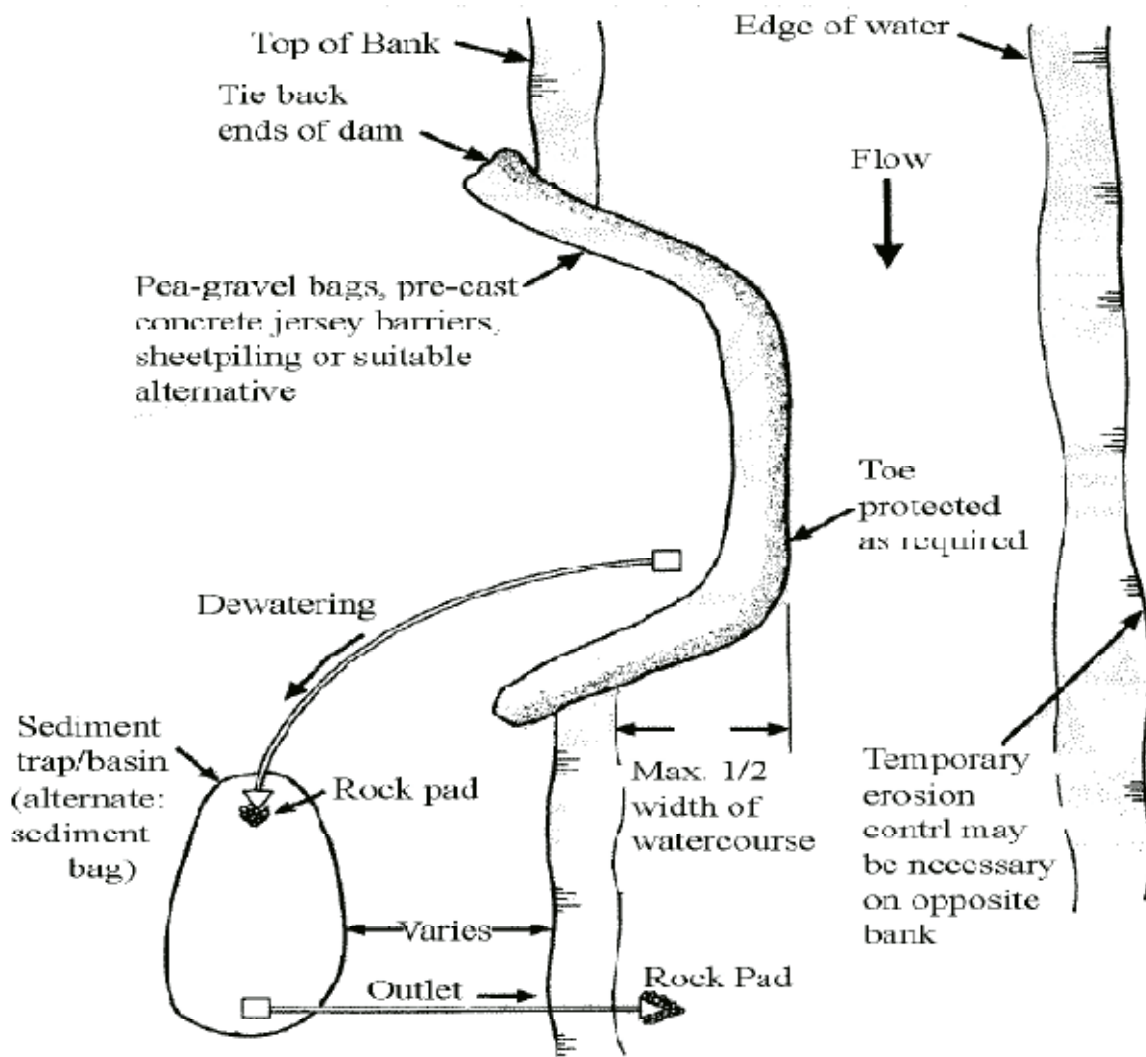
- In areas of shallow flow depth (less than 1.5 m)
- Constant pumping may be required to keep work area dewatered

Construction (Note: *For guidance only. A site specific design is required from designer/engineer*)

- Encroachment into watercourse should be minimized
- Cofferdam should not cause unacceptable sewer and flow velocities in the watercourse
- Height of the dam should provide protection for a 10 year event, if possible (height of dam to be less than 1.5 m)
- All debris and accumulated sediment must be cleared away before removal of the coffer dam
- Operations within the work area must be capable of withstanding inundation without risk to life and equipment damage

Inspection and Maintenance

- Dams should be inspected regularly and immediately repaired if required. A thorough inspection should be conducted following flood events
- Water removed from work area may be silty and should be discharged to a vegetated area at least 30 m from the watercourse, or pumped through a filter bag
- The weather forecast should be monitored to anticipate the occurrence of high flow events. Work operations should be adjusted to accumulate possible overtopping of the coffer dams



Source: Greater Golden Horseshoe
Conservation Authorities

Description and Purpose

- A barrier of strawbale primarily used as a perimeter sediment control measure
- May be used to intercept and retain sediment laden runoff allowing a portion of the sediment load to be retained

Applications

- Temporary measure
- Suitable for flow velocities of 0.3 m/s or less
- Usually placed at 1m to 2 m offsets from toe of disturbed slopes
- Size of drainage area should be no greater than 0.1 ha per 30 m length of straw bale sediment barrier
- Maximum flow path length upstream of barrier should be less than 30 m
- Maximum slope gradient above the barrier should be no greater than 2H:1V
- May be used in conjunction with filter fabric as external wrap to encapsulate the bale

Advantages

- Straw bales are biodegradable
- Only requires one row of straw bales
- Easier to install than other barriers and economical if straw bales are readily available

Limitations

- Not appropriate for flow velocities greater than 0.3 m/s
- Require extensive maintenance following high velocity flows associated with storm events
- Not as robust as earth berms or continuous berms
- Susceptible to undermining and erosion damage if not properly keyed into substrate soil or if joints are not completely infilled with straw
- Short service life
- Must be installed by hand
- Not to be used on asphalt or concrete covered surfaces
- Availability of appropriate bales may be limited in certain areas of the province
- Maximum straw bale barrier height of one straw bale or 0.5 m maximum height

Construction

(Note: For guidance only. A site specific design is required from designer/engineer)

- Straw bale barrier should be located a minimum distance 1.8 m away from the toe of the slope to provide adequate ponding and sedimentation area
- Excavate a trench approximately 0.10 m deep with a width of one straw bale at the straw bale barrier location
- Place straw bales in excavated trench along contour, perpendicular to flow direction
 - Ensure twine or wire is not in contact with the soil
 - Ensure straw bale is in continuous contact with base of trench
 - Ends of barrier should be angled upslope to form enclosure to contain runoff
- Infill all joints with loose straw
- Drive two 50 mm by 560 mm section wooden stakes 1.2 m long through each straw bale, ensuring each stake is embedded a minimum of 0.15 m into soil
- Backfill and compact the upstream and downstream edges of the check structure to seat the straw bales into the subgrade

Construction Considerations

- Maximum lengths of barriers should be 40 m, including 'J- hook' or 'smile' (similar to silt fence in BMP #18) configuration, to allow escape route for excess runoff
- Barrier should be placed far enough away from toe of slope to provide adequate ponding and sedimentation area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of barriers should be angled upslope (in a 'J-hook' or 'smile' configuration) to form enclosure to collect runoff
- Straw bales should be:

Straw Bale Barrier <i>Sediment Control</i>	BMP 10
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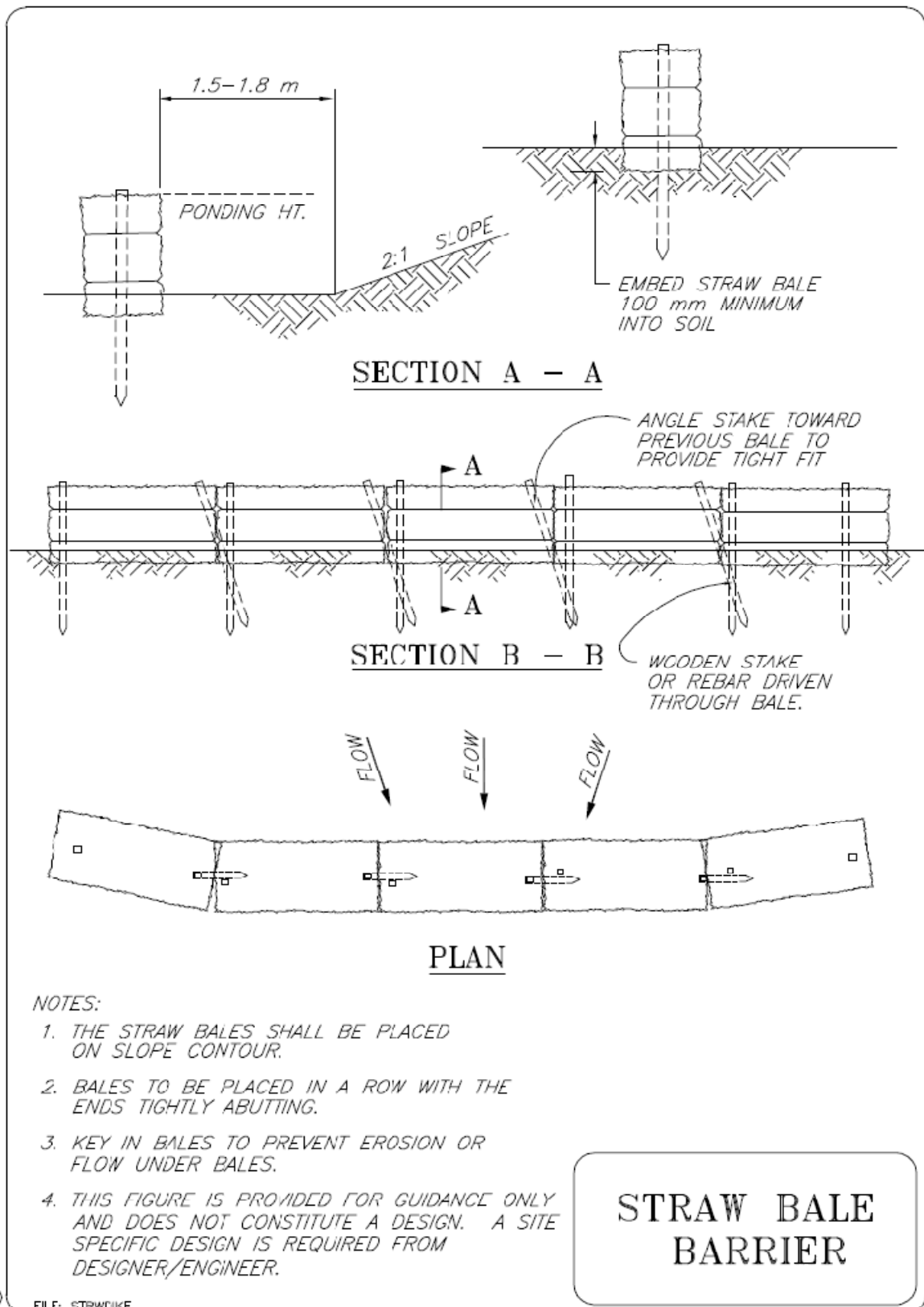
- Machine-made
- Weed free cereal crop straw such as wheat, oats, rye, or barley
- Tightly compacted and bound with two rows of wire or synthetic string and shall show no signs of weathering
- No more than one year old

Inspection and Maintenance

- Inspect barriers at least at weekly intervals and after each significant rainfall event (more than 25 mm in a 24 hour period)
- Remove sediment build up before it reaches one half the check barrier height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace damaged, decayed or dislodged straw bales immediately

Similar Measures

- Silt fences
- Continuous (earth- filled geotextile) berms
- Earth Dyke Barrier



From: Salix—Applied Earthcare — EROSION DRAW 3.0
1994 JOHN McCULLAH

FILE: STRWDIKE

Description and Purpose

- Barrier constructed of compacted soil to intercept and divert flow of runoff water away from sensitive areas or water bodies
- A spillway outlet of erosion-resistant granular material constructed to allow exit of diverted water to less sensitive areas.

Applications

- Temporary or permanent measure
- Used instead of (or in conjunction with) diversion ditches
- Perimeter control
- Placed along contours at toe of slope to divert run-off from sensitive areas
- Used to divert water to sediment control structures

Advantages

- Easy to construct
- Can be converted to sedimentation/impoundment pond with the design of a permeable filter berm at the exit spillway area (see drawing)

Limitations

- Generally, earth dyke barrier can be 1 to 2 m in height. Design by a geotechnical engineer is required for barriers greater than 3 m in height in accordance with dam design guidelines and regulatory requirements. The consequences of failure will influence the level of design and construction requirements.

Construction

(Note: For guidance only. A site specific design is required from designer/engineer)

- Construct barrier from bottom up by placing and compacting subsequent lifts of soil
- Degree of compaction of each lift to be determined by the design engineer based on consequences of failure

Construction Considerations

- The barrier shall be trapezoidal in section
- Low barriers should have the slopes tailored to the construction material used
 - 1.5H:1V for granular soils (predominantly gravel)
 - 2H:1V or flatter for compacted mixed or fine grained soils
 - Slope should be flattened to a minimum of 3H:1V for uncompacted fine grained soils

Inspection and Maintenance

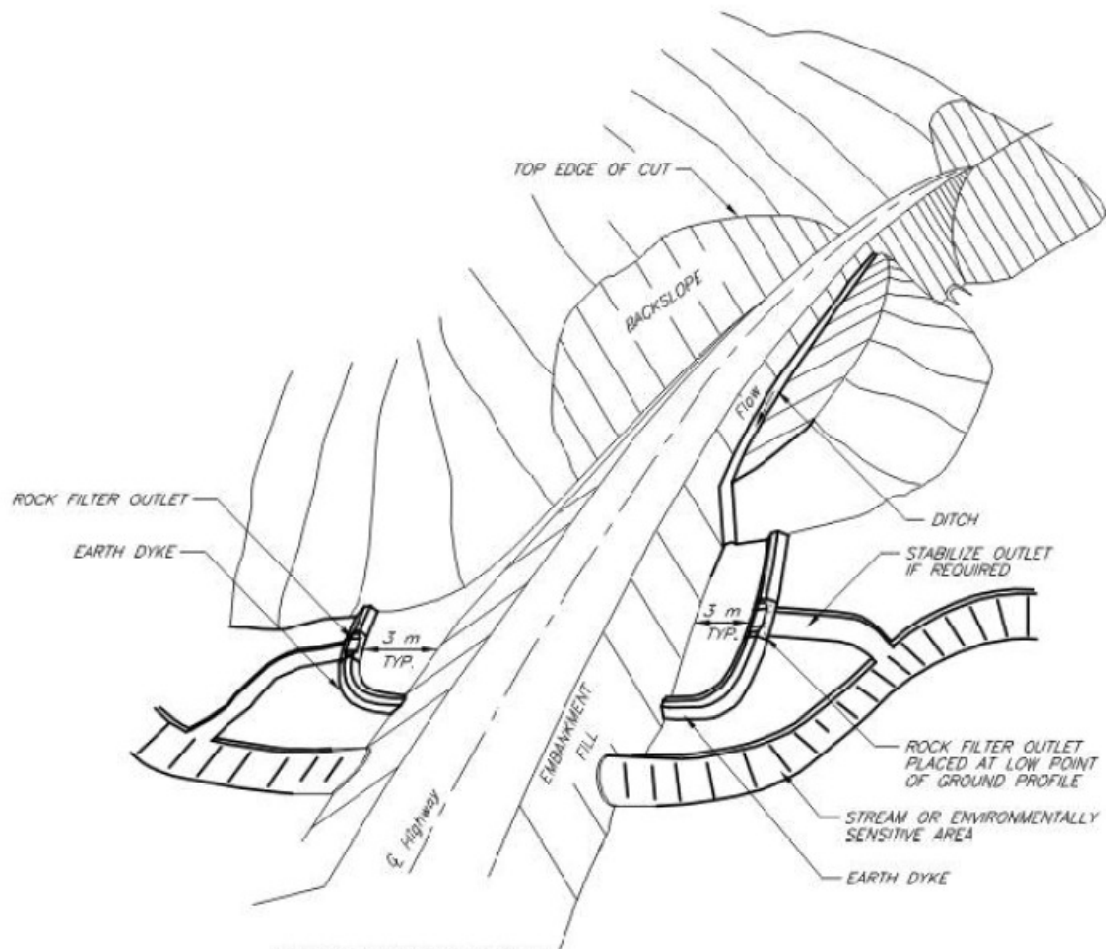
- The degree and extent of inspection and maintenance performed on an earth dyke barrier is directly related to the consequences of failure. Depending on the consequences of failure, an engineer experienced in embankment design and inspection may be required for inspection, design of remedial measures and supervision of their implementation.
- Inspect barriers on a weekly basis and before and after significant rainfall events (1:2 year storm and/or 40 mm rainfall over 24 hour duration)
- Piping failures may be remedied by replacing saturated soils with drier compacted soil and/or by placement of geotextile over the failed area and placing a stabilizing toe berm constructed in the granular materials over the non-woven materials where disturbance is evident
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-half the barrier height
- Deactivate and remove barrier once soils upslope have stabilized and return barrier location to conditions that are equivalent or better than prior to barrier construction

Similar Measures

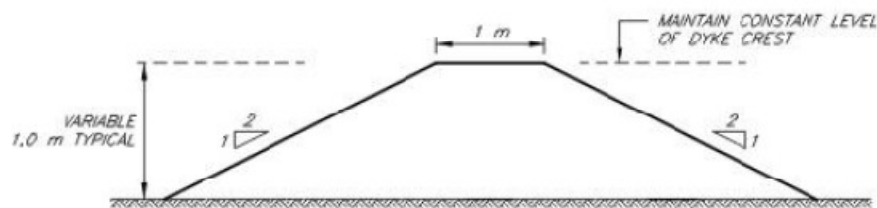
- Berms
- Sand/Gravel Bag Barriers

Design Considerations

- Geotechnical design required for barriers constructed of fine grained soils and greater than 3 m in height



EARTH DYKE BARRIER
TYPICAL LOCATION



TYPICAL SECTION
EARTH DYKE

NOTES:

1. SILT ACCUMULATION TO BE REMOVED WHEN HALF EARTH DYKE HEIGHT COVERED.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**EARTH DYKE
BARRIER**

Brush or Rock Berm

Velocity Dissipation

BMP 12

Description and Purpose

- Temporary barriers of brush wrapped in filter fabric and secured in place, or rock anchored in place to intercept and filter sediment laden stormwater runoff from disturbed areas, retain sediment, and release water as sheet flow

Applications

- Temporary measure
- Perimeter control
- Near toe of slopes subjected to sheet flow and rill erosion
- Along crest or tops streams and channels
- Around drain inlets
- Maximum drainage area of less than 250 m² per 25 m length of barrier

Advantages

- May be equally effective filter as silt fences

Limitations

- Temporary measure only
- Maximum drainage area of less than 250 m² per 25 m length of barrier
- Sufficient area behind berm required for ponding and clean out of sediment
- Not effective for diverting runoff (filters allow runoff to seep through)
- Rock filter berms are expensive to remove at completion of service life
- Not to be used across ditches, channels, or swales where high concentrated flows are anticipated

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- Brush filter berm
 - Size of the brush filter berm will vary depending upon amount of material available and condition of the site
 - The height of the berm shall be at least 1 m tall and the width shall be a minimum of 1.5 m at its base
 - Berm is constructed by piling brush, roots, stumps and/or stones into a mounded row along contours
 - During clearing and grubbing, equipment can push the material into windrows along toe of slopes or other areas prone to erosion
 - Filter fabric is then laid across the berm, with edges overlapping, and secured in a trench immediately upstream of the berm
 - Trench shall be 15 cm wide and 15 cm deep and shall run for the entire length of the berm
 - The filter fabric in the trench shall be staked down with stakes spaced approximately 1 m apart
 - The trench is then backfilled and compacted over the staked filter fabric
 - The fabric is anchored with twine/wire to stakes on the downstream side of the berm

Brush or Rock Berm

Velocity Dissipation

BMP 12

- Rock filter berm
 - Constructed similar to brush filter berm, replacing brush with rock (D50 = 75 mm to 150 mm)

Construction Considerations

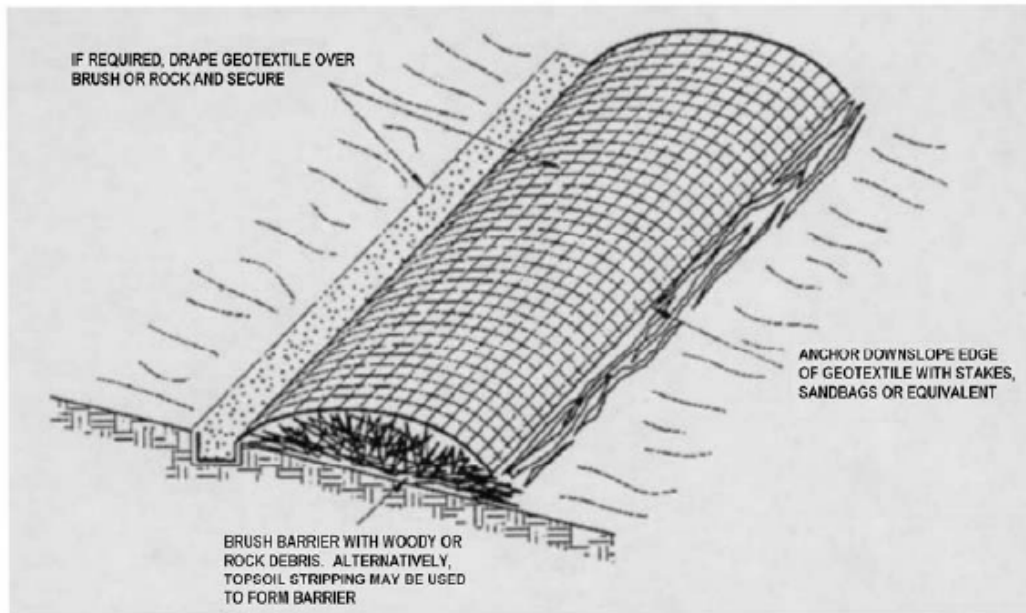
- Use rock or brush material smaller than 150 mm in diameter, or use filter cloth to encapsulate the material, to promote filtration
- There is no predetermined shape for filters
- Water must be forced to filter through the berm and not flow around it
- Brush barriers can generally be constructed of clean organic material made available from clearing and grubbing operations that is normally burned or discarded
- Rock and brush filter berms are temporary measures and should be removed upon completion of service life, but not prior to revegetation of areas upslope

Inspection and Maintenance

- Inspect berms on a weekly basis and before and after significant rainfall events (1:2 year storm event and/or 40 mm rainfall over 24 hours duration)
- Reshape berms as needed and replace lost or dislodged rock, brush, and/or filter fabric
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-third the berm height or 300 mm, whichever occurs first
- Inspect for toe undercutting, weathered/deteriorated filter fabric, and end runs and erosion of the filter and repair immediately

Similar Measures

- Berms/Barriers
- Check Dams
- Permeable/Synthetic Barriers
- Sand/Gravel Bag Barriers
- Design Considerations
- Material properties
 - Rocks
 - Shall consist of hard, durable, clean mineral particles free of organic matter, clay lumps, soft particles, or other substances that might interfere with drainage and filtering properties
 - D50 of 75 mm to 150 mm preferable
- Brush
 - Material shall be less than 150 mm in diameter



NOT TO SCALE

NOTES:

1. EXCAVATE 150 mm X 150 mm TRENCH ALONG UPSTREAM SIDE OF BRUSH OR ROCK BERM.
2. DRAPE GEOTEXTILE OVER BRUSH OR ROCK BERM ENSURING UPSTREAM SIDE IS IN TRENCH.
3. BACKFILL AND COMPACT SOIL OVER GEOTEXTILE IN EXCAVATED TRENCH.
4. SECURE GEOTEXTILE OVER BRUSH OR ROCK BERM BY STAKING ON DOWNSTREAM SIDE OF BERM.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**BRUSH or ROCK
BERMS**

Description and Purpose

- Small dam constructed across a drainage channel
- May be constructed of rock, aggregate-filled sandbags or logs
- Decrease flow velocities to reduce erosion caused by storm runoff
- Sediment laden runoff is retained allowing sediment to settle out

Applications

- Temporary or permanent measure
- Reduces long steep grade to intervals of gentle grades between structures
- Reduces flow velocities to decrease erosion potential caused by runoff
- Sediment laden runoff is retained behind structure allowing sediment to settle out
- May be used in channels that drain 4 ha or less
- May be used in steep channels where runoff velocity is less than 1.5 m/s

Advantages

- More effective than straw bales for stabilizing medium to steep gradient ditches as a permanent measure
- Cheaper than using riprap armouring or gabion structures in a ditch
- Rock and sandbag structures are relatively easy to construct
- Cement can be incorporated into sandbag aggregates for a permanent application
- Timber structures are suited to areas where timber can be salvaged from clearing operations and other materials are in short supply

Limitations

- Not appropriate for flow velocities greater than 1.5 m/s
- Not appropriate for channels draining areas larger than 4 ha (10 ac)
- Not appropriate for grass lined channels unless erosion is anticipated
- Susceptible to failure if water undermines or outflanks structure
- Timber structures are labour intensive to construct, gaps between logs may render them ineffective and they will decay and rot with time

Construction (Rock Check Dam)

(Note: For guidance only. A site specific design is required from designer/engineer.)

- Excavate a trench key a minimum of 0.15 m in depth at the rock check structure location
- Place non-woven geotextile fabric over footprint area of rock check structure
- Construct structure by machine or hand
- Structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of structures should be less than 0.8 m in height to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 3H:1V (minimum)
- Upstream slope of the check dam should be 2H:1V (minimum)

Construction Considerations (Rock Check Dam)

- Height and spacing between structures should be designed to reduce steep channel slope to intervals of flatter gradient
- Rock check structures should be constructed of free draining aggregate
- Aggregate used should have a mean diameter (D50) of between 75 mm and 150 mm and must be large enough to remain in place during high velocity flow situations.
- Maximum rock diameter should not exceed 150 mm if the structure is to be used as a sediment trap.
- If rock check structures are in channels with significant high flows, they must be properly designed for stone size and structure spacings

Construction (Sandbag Check Dam)

(Note: For guidance only. A site specific design is required from designer/engineer.)

- Place sandbags by hand at check structure location with geometry similar to that shown for the rock check dam
- Check structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of check structures should be less than 0.8 m to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 2.5H:1V (minimum)
- Upstream slope of the check dam should be 1.5H:1V (minimum)

Construction Considerations (Sandbag Check Dam)

- Height and spacing of check structures should be designed to reduce channel slope to intervals of flatter gradient
- Sandbags should only be filled $\frac{3}{4}$ full to allow bag to mould to contours, allowing continuous contact between the bag and the soil

Construction (Log Check Dam)

(Note: For guidance only. A site specific design is required from designer/engineer.)

- Embed ends of logs at least 0.5 m into channel or ditch bed
- Ensure there are minimal gaps between logs
- Install horizontal cross brace at top of the downstream side of structure to connect logs together providing integral support
- Structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- To avoid impounding large volumes of runoff, check structures should be less than 0.5 m in height above the base of the ditch.

Construction Considerations (Log Check Dam)

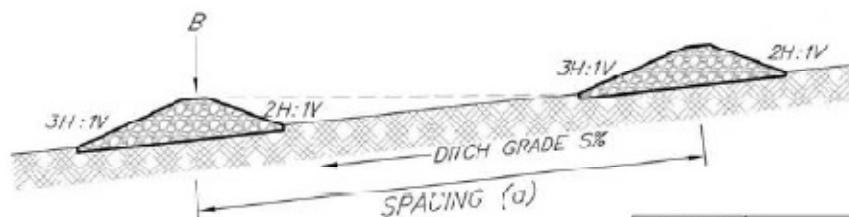
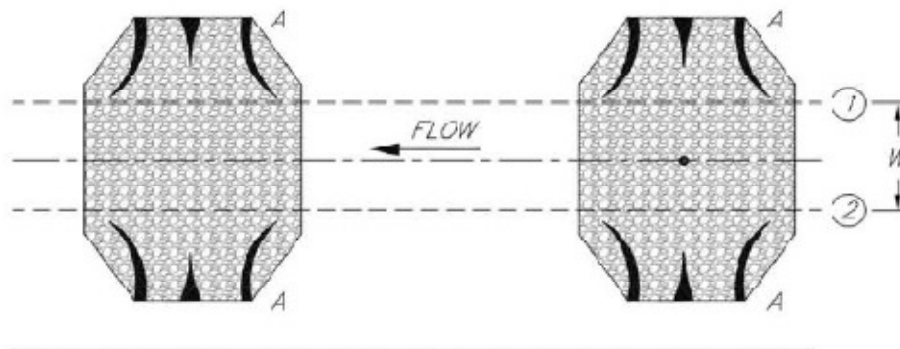
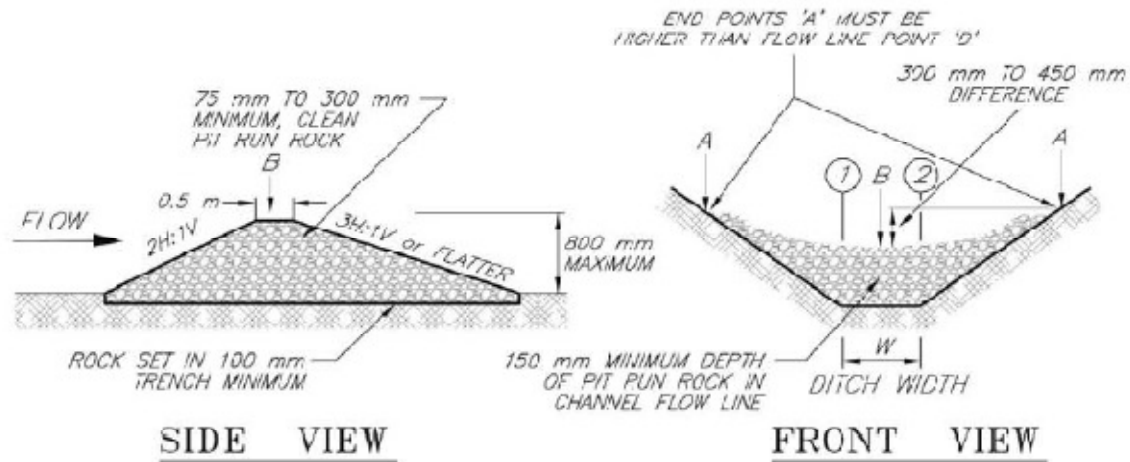
- Height and spacing of structures should be designed to reduce gradient to a flatter grade
- Wood check dams placed in ditches with high anticipated flow velocity should have their spacing and height design according to the anticipated hydraulic condition
- Bracing should be installed to provide support to embedded logs

Inspection and Maintenance

- Inspect barriers at least once a week and before and after each significant rainfall event (more than 25 mm in a 24 hour period)
- Remove sediment build up before it reaches one half the check structure height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace dislodged materials immediately or consider a more robust structure

Similar Measures

- Synthetic permeable barrier



NOTES:

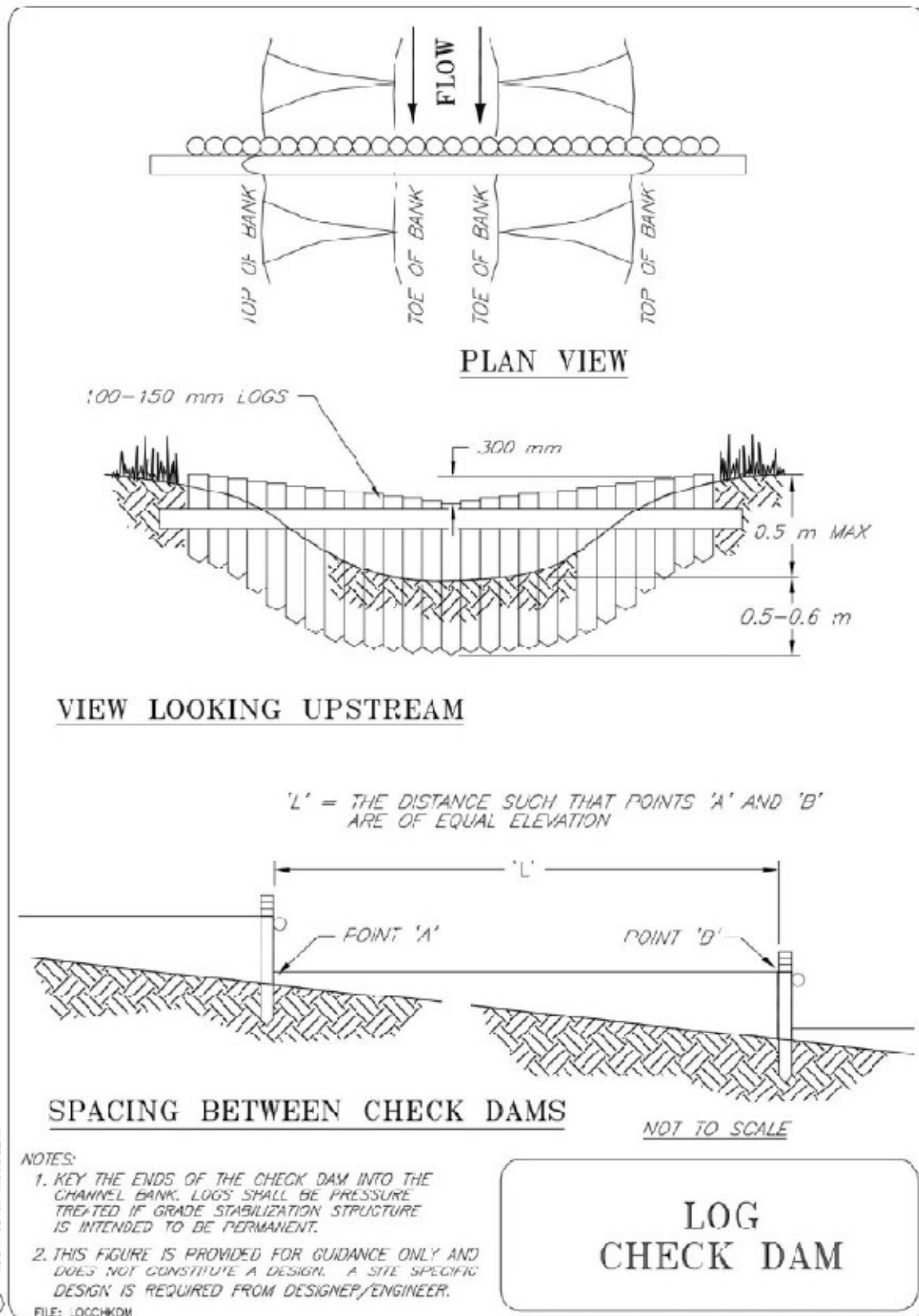
1. SUITABLE FOR FLOW VELOCITY ≤ 1.5 m/s.
2. SUITABLE FOR DRAINAGE AREA ≤ 1 ha.
3. SUITABLE FOR GRADES FROM 5% TO 8%.
4. SPACING (d) AND ROCK SIZE (D_{50}) TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

D_{50} OF ROCK (mm)	MAXIMUM FLOW DEPTH OVER ROCK (mm)
75	50
150	100

SUGGESTED ROCK DIAMETER AND OVERFLOW DEPTHS

ROCK CHECK DAM



From: Soil-Applied Erosion - EROSION DRAW 3.0
1994 JOHN McCULLAH

Check Dam Velocity Dissipation

BMP 13

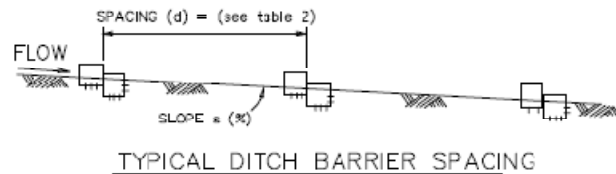
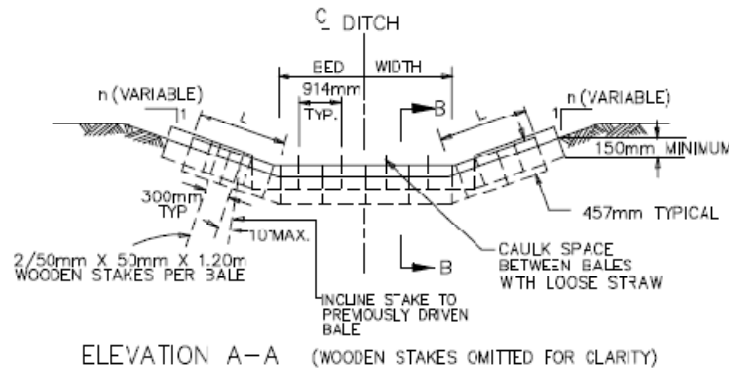
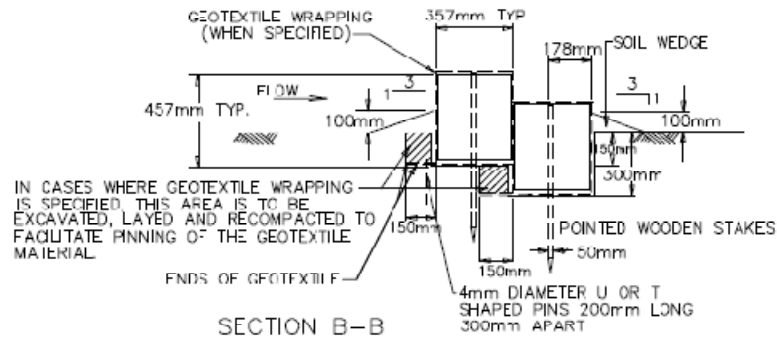
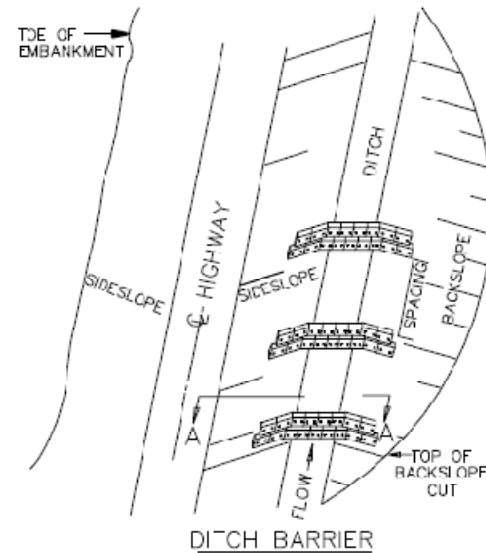


TABLE 1 MINIMUM INSTALLATION LENGTH UP SLOPES	
SLOPE n	LENGTH L (m)
2	1.0
2.5	1.25
3.0	1.50
3.5	1.65
4	1.80
5	2.35
6	2.75

TABLE 2 SUGGESTED SPACING (d)	
S (%)	d (m)
3	40
4	35
5	25

NOTES:

1. SUITABLE FOR $S < 5\%$ AND HYDRAULIC CONDITIONS NOT SEVERE. FOR $S > 5\%$, THE ENGINEER MUST ASSESS USE OF THIS STRUCTURE VERSUS OTHER OPTIONS.
2. EMBED BALES 100 TO 150 mm. INTO THE SOIL AND "KEY BALES INTO THE CHANNEL BANKS.
3. PLACE BALES PERPENDICULAR TO THE FLOW WITH ENDS TIGHTLY ABUTTING.
4. BALE HEIGHT SHALL NOT EXCEED 0.5 m.
5. INSPECT AFTER EACH SIGNIFICANT STORM, MAINTAIN AND REPAIR PROMPTLY.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.



STRAW BALE CHECK DAM

Source: Alberta Transportation BMP #11 / Typical Section

Energy Dissipators

Velocity Dissipation

BMP 14

Description and Purpose

- a) Hard armour (rip rap, gravel, sand bags, concrete) placed at pipe outlets, in channels, and at downstream side of check structures to reduce velocity and dissipate energy of concentrated flows
- b) Standard Drain Trough Terminal Protection Structure generally used at bridge headslope
- Minimizes scour at flow impact location with dissipated flow energy

Applications

- Permanent measure
- May be used at outlets of pipes, drains, culverts, conduits, or channels with substantial flows
- May be used at slope drain outlets located at the bottom of mild to steep slopes
- May be used where lined channels discharge into unlined channels
- May be used as splash pad on downstream side of gabions, check structures, berms, barriers, and silt fences to prevent erosion caused by overtopping of structure

Advantages

- Reduces flow energy in a relatively small area

Limitations

- Small rocks or stones can be dislodged during high flows
- Grouted rip rap may breakup due to hydrostatic pressure, frost heave, or settlement
- May be expensive if construction materials (rip rap, gravel, or concrete) is not readily available
- May be labour intensive to place and construct
- Extreme flow velocities may require paved outlet structures, stilling basins, plunge pools, drop structures, baffles, or concrete splash pads which will require special design by qualified personnel. Energy dissipators constructed of rip rap may not be adequate for extreme flow velocities

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- Grade the area to final design grades and elevations
- Sub-excavate energy dissipator location to thickness of energy dissipator
- Place filtration bedding material on base of excavation
 - Bedding can be comprised of well graded sand and gravel or non-woven geotextile
 - Acts as separating filter between fine grained subgrade and riprap size energy dissipator material
 - Place energy dissipator material (rip rap, gravel, sand bags, concrete) over filtration bedding material
 - Top of energy dissipator should be flush with surrounding grade
- Construction Considerations
- Length of energy dissipator (L_a) at outlets shall be of sufficient length to dissipate energy
 - $L_a = 4.5 \times D$ (where D is the diameter of the pipe or channel at the outlet)
 - Energy dissipator should extend upstream of the outlet approximately a minimum distance of $0.5 \times D$
- Width of energy dissipator (W_a) at outlets shall be of sufficient width to dissipate energy $W_a = 4 \times D$
- Thickness of energy dissipator (d_a) at outlets shall be of sufficient thickness to dissipate energy
 - $d_a = 1.5 \times \text{maximum rock diameter}$ (with a minimum thickness of 0.30 m)
- Energy dissipator (splash pad, apron) shall be set at zero grade and aligned straight, with the direction of flow at the outlet
- Bedding (filtration) layer can comprise either non-woven geotextile or a minimum of 0.15 m well graded sand and gravel layer
- Energy dissipator should be constructed of well- graded rip rap
 - Minimum $d_{50} = 150$ mm. Preferable $d_{50} = 300$ mm
 - Minimum thickness = a) $1.5 \times d_{50}$ or b) 0.30 m to 0.45 m thickness. (a or b whichever is greater)
- Energy dissipator shall be designed to accommodate a 10- year peak runoff or the design discharge of the upstream channel, pipe, drain, or culvert, whichever is greater
- The energy dissipator shall be constructed flush with the surrounding grade and shall be directly in line with direction of outlet flow

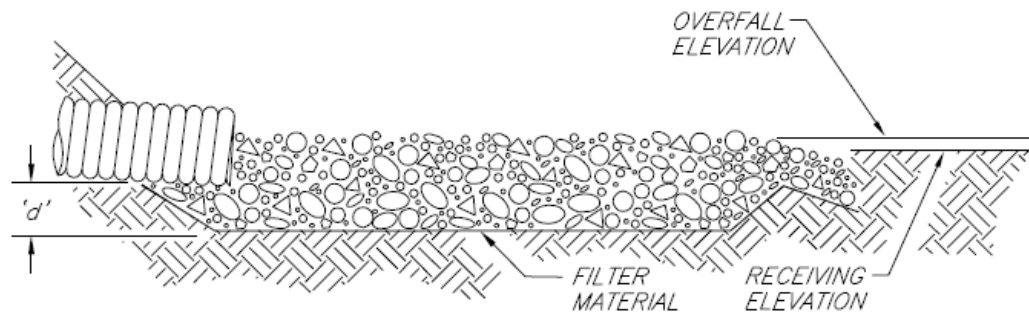
Inspection and Maintenance

Energy Dissipators <i>Velocity Dissipation</i>	BMP 14
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- Periodic inspections to check for damage should occur at least once a month, or after storm events (1:2 year storm and/or 40 mm rainfall over 24 hour duration)
- Any damage should be repaired immediately

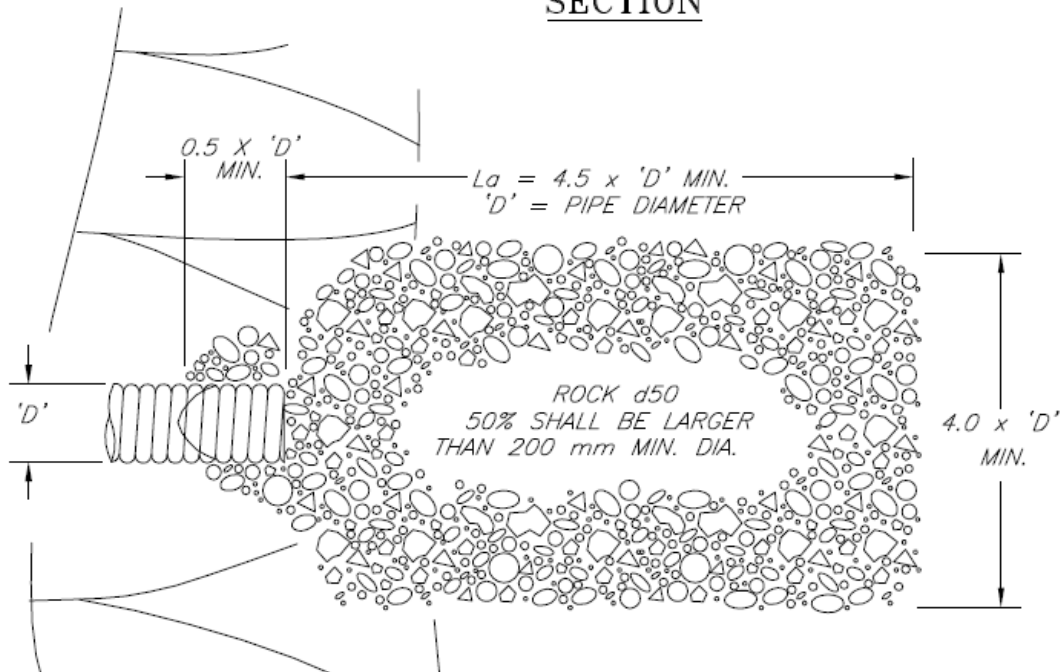
Similar Measures

- Gabion mattresses



B) MINIMUM THICKNESS = 300 mm. (i.e. $1.5 \times D_{50}$) FOR $D_{50} = 200$ mm.

SECTION

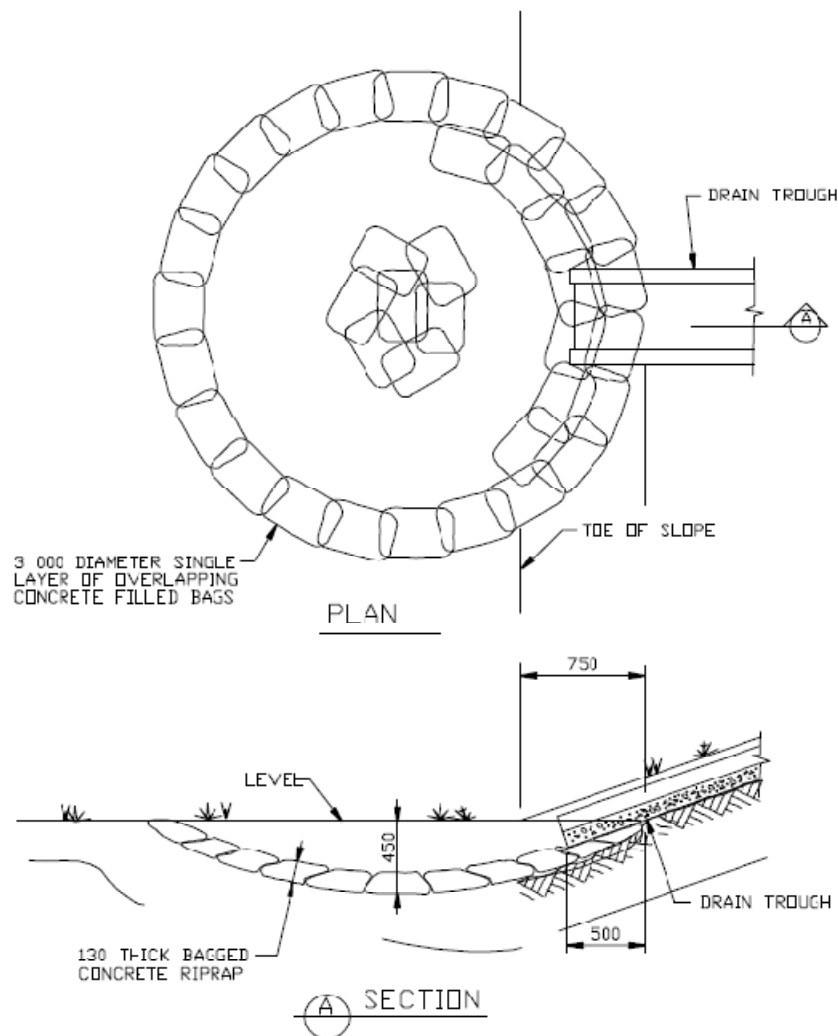


PLAN

NOTES:

1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 150 mm THICK MINIMUM GRADED GRAVEL LAYER.
4. FOR PIPE DIAMETER > 600 mm, DESIGN BY ENGINEER IS REQUIRED.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**ENERGY DISSIPATOR
FOR CULVERT OUTLET**



GENERAL NOTES

- DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE.
- PLACING OF BAGGED CONCRETE RIPRAP SHALL START AT THE BOTTOM CENTRE OF THE DISHED AREA AND SHALL PROCEED IN A CONTINUOUS SPIRAL FASHION OUTWARD UNTIL THE ENTIRE DISH IS COVERED. EACH CONCRETE FILLED BAG SHALL LAP OVER THE EDGES OF THE PREVIOUSLY PLACED BAGS.

SOURCE: ALBERTA TRANSPORTATION SPECIFICATIONS FOR BRIDGE CONSTRUCTION
 DRAWING S-1410-91

- THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**ENERGY DISSIPATOR
 FOR SEMI-CIRCULAR TROUGH
 DRAIN TERMINAL PROTECTION
 FOR BRIDGE HEADSLOPE**

Cross Culverts <i>Velocity Dissipation</i>	BMP 15
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Offtake Ditch (Intercept Ditch) <i>Velocity Dissipation</i>	BMP 16
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Description and Purpose

- Channels or swales commonly located along the crest of cuts slopes to intercept and convey runoff away from flowing down a newly excavated bare soil slope and to minimize erosion of slope from overland sheet flow
- Can be tied to outfall to slope drains (or downdrains) which carry water from higher slope elevations to lower elevation of a slope

Applications

- Permanent measure
- Effective method of intercepting runoff to avoid excessive sheet flow over slope and causing erosion, especially on cut slopes in highly erodible soils (sand and silt)
- Can be used in conjunction with slope drains which was installed down a large cut slope
- May be lined with vegetation, rip rap, erosion control blankets, or some other erosion protection measure, but this requirement may be appropriate only at highly sensitive and high risk environmental areas
- Can be used in conjunction with sediment control measures, such as check structures or permeable synthetic barriers as normal channel design, but this requirement may be appropriate only at highly sensitive and high risk environmental areas

Limitations

- Ditch may require lining to minimize soil erosion from concentrated flow
- Ditch may require design by qualified personnel if flow velocities and/or volumes are large
- Channel must be graded to maintain adequate depth, positive drainage to avoid ponding and breaching of channel flow, which may lead to overtopping of the channel to result flow to cause in downslope erosion
- Removal of sediment build up and ditch maintenance may be difficult due to limited access space as offtake ditches are commonly constructed at crest of slopes

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- Use backhoe to form ditch a minimum offset distance of 2 m between crest of highway slope and top of offtake ditch sideslope, thus providing a dyke width of 1 m
 - Place and compact excavated soil to form a dyke between crest of highway slope and offtake ditch channel to provide adequate depth (1 m) of the offtake ditch
 - The consequence of failure on this dyke will determine the level of compaction effort required
 - Sideslopes of ditch should not be steeper than 2H:1V (depending upon material type)
 - Depth of ditch (from base of ditch to top of embankment) should be a minimum of 1 m in depth; width of ditch should be 1 m minimum
 - Ditch grade should be graded a minimum of 1% to promote positive drainage and outfall

Construction Considerations

- Channel should be graded towards nearest outfall (draw) or drainage pipe

Inspection and Maintenance

- Inspect ditches at least at biweekly intervals and after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Repair any damage to channel immediately

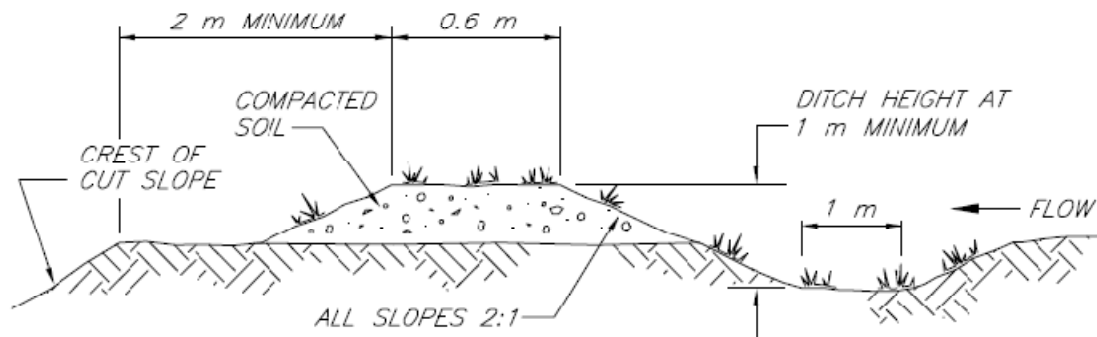
Similar Measures

- Berms
- Barriers

Offtake Ditch (Intercept Ditch) <i>Velocity Dissipation</i>	BMP 16
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Offtake Ditch (Intercept Ditch)
Velocity Dissipation

BMP 16



TYPICAL OFFTAKE DITCH

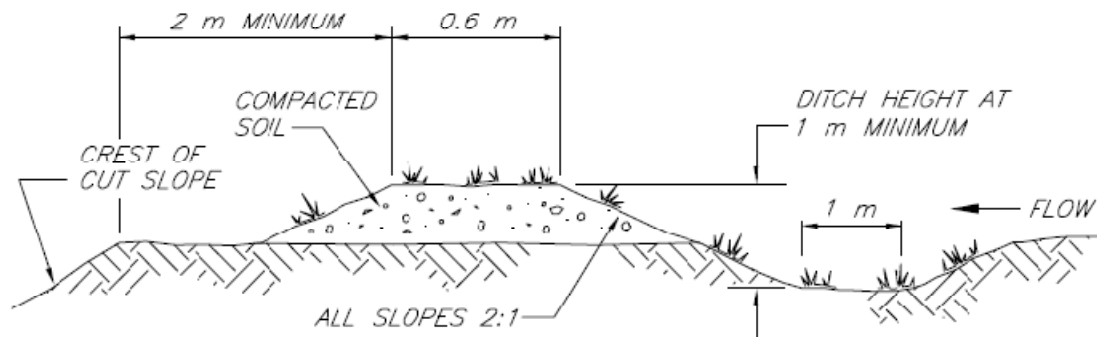
NOTES:

1. THE DITCH BEHIND THE DYKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
2. THE DYKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.
3. FOR SENSITIVE HIGH RISK AREAS, THE DITCH SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

**OFFTAKE DITCH
(INTERCEPT DITCH)**

Offtake Ditch (Intercept Ditch)
Velocity Dissipation

BMP 16



TYPICAL OFFTAKE DITCH

NOTES:

1. THE DITCH BEHIND THE DYKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
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**OFFTAKE DITCH
(INTERCEPT DITCH)**

Slope Drains (Temporary Pipes)

Velocity Dissipation

BMP 17

Description and Purpose

- Heavy duty, flexible pipe "Big O" that carries water from top to bottom of fill or cut slope to prevent concentrated water flowing downslope and eroding face of slope

Applications

- Temporary or permanent measure
- Used on cut or fill slopes where there is a high potential for upslope runoff waters to flow over the face of the slope causing erosion, especially at areas where runoff converges resulting in concentrated runoff flows (e.g. possible breach of low catchwater ditch at top of a cut slope)
- Used in conjunction with some form of water containment or diversion structures, such as diversion channels, berms, or barriers, to convey upslope runoff water and direct water towards slope drain

Limitations

- Pipes must be sized correctly to accommodate anticipated flow volumes
- Water can erode around inlet if inlet protection is not properly constructed
- Erosion can occur at base if outlet protection or energy dissipator is not constructed
- Slope drain must be anchored securely to face of slope

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

- Construct diversion or intercept channel, ditch block, barrier, or other inflow apron structure at crest of slope to channel flow toward the slope drain inlet
- Install slope drain through inlet berm or barrier with a minimum of 0.45 m of soil cover above top of drain pipe to secure the inlet
 - Install scour inlet protection (such as rip rap, sand bags)
- Install energy dissipator (such as rip rap, gravel, concrete) at downslope outlet end of slope drain
 - Outlet must not discharge directly onto unprotected soil
- Secure the pipe from movement by tying to steel anchor stakes, hold-down grommets, or other approved anchor method
 - Space anchors on each side of drain pipe at maximum 3 m intervals along entire length of drain pipe

Construction Considerations

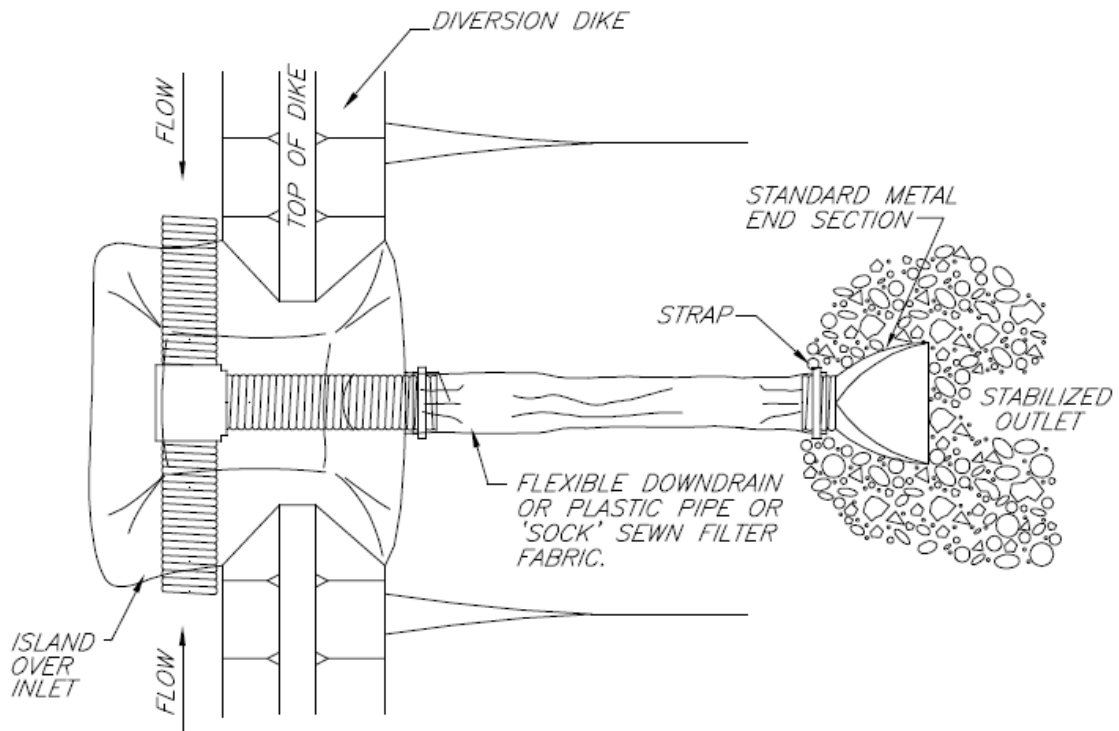
- Use coiled drain pipe for low flows only
- If constructing inflow apron at crest of slope out of sandbags, only fill each sandbag $\frac{3}{4}$ full, this will allow sandbag to be flexible enough to mould around drain pipe and remain in continuous contact with the ground
- Several slope drains may be required if upslope drainage areas are too large for one drain pipe

Inspection and Maintenance

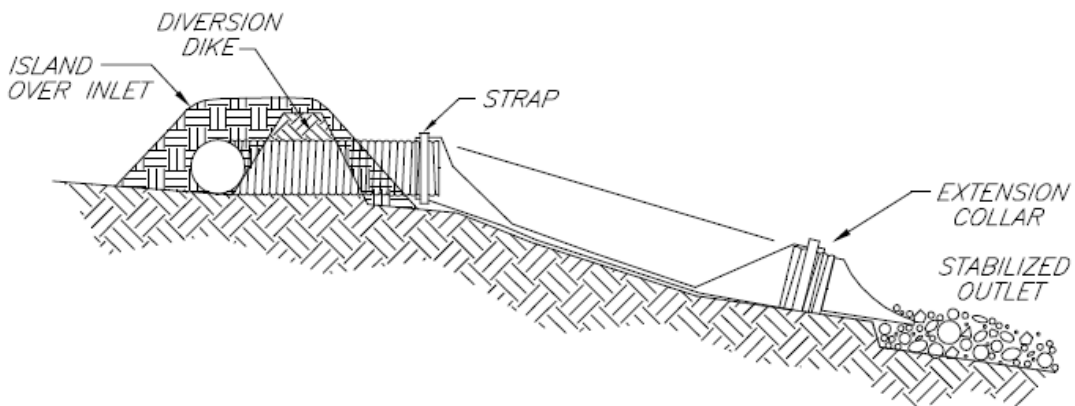
- Inspect slope drains at least once per week, or after significant storm events (1:2 year storm and/or 40 mm precipitation in 24 hours)
- Repair any damaged section of pipe immediately
- If evidence exists of pipe movement, install additional anchor stakes to secure and anchor at zones of movement
- Remove sediment from upslope inflow apron area after each storm event otherwise either downslope sediment transport will occur or cause the drainpipe to be plugged which could result in overtopping of inflow apron structure and sheet flow over slope face.

Similar Measures

- Rock lined channel
- Permanent Pipe (slope drains)
 - Corrugated steel pipe (CSP) down drain (AT Drawing No. CB-6 2.4 M17)
 - Half-round corrugated steel (1/2 CSP) downslope drain (AT Drawing No. CB-6 2.4 M4) for low flow areas such as bridge head slopes



PLAN VIEW



SECTION

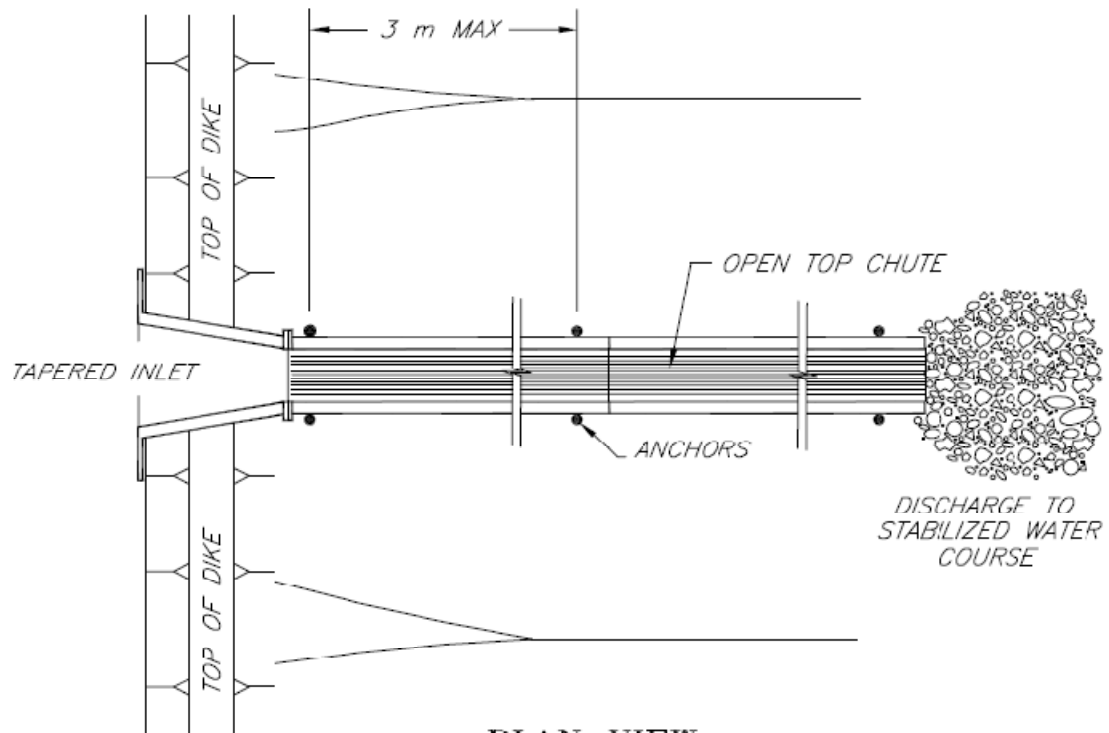
NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

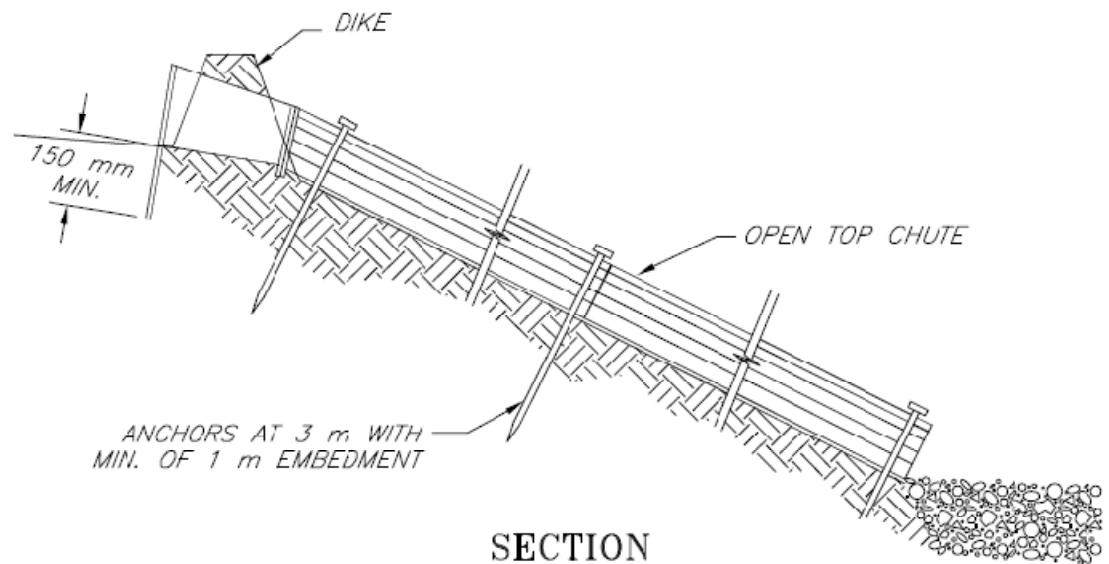
SLOPE DRAIN

Slope Drains (Temporary Pipes) Velocity Dissipation

BMP 17



PLAN VIEW



SECTION

NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

OVERSIDE DRAIN

Description and Purpose

- The planting or placing seed into soils of cut slope or fill embankment slopes after a layer of organic topsoil is spread over the slope
- Provides erosion protection through development of a shallow root structure from seed germination and plant growth

Applications

- Permanent or temporary measure
- Temporary seeding with rapidly growing plants may be applied to stockpile or excavation areas which will be exposed for more than 30 days
- Permanent seeding may be applied to exposed bare soil areas which have been graded to final contours
- Permanent seeding may be applied to landscape corridors, slopes and channels by broadcasting, furrowing or spraying on with mulch tackifier
- Provides habitat for wildlife after vegetation establishment
- Can be enhanced with a protective layer of mulches or rolled erosion control products (RECP) to improve growth environment

Advantages

- Enhances terrestrial and aquatic habitat with vegetation growth re-establishment
- Aesthetically pleasing with vegetation cover
- Grows stronger with time as root structure develops
- Generates vegetation to enhance infiltration of runoff and evapotranspiration
- Seeding with a mixture of grasses and herbaceous legumes in disturbed areas is an inexpensive method of stabilizing soil, particularly if the area is flat or gently sloping
- Cost of seeding disturbed areas is relatively low and its effectiveness on a long-term basis is relatively high

Limitations

- Grasses may require regular maintenance (mowing) along ditches
- Uncut dry grass may present a fire hazard and site distance obstruction adverse to highway safety
- Seeding of steep slopes may be difficult without using measures such as RECP's or hydroseeding-hydromulching methods
- Seasonal windows on planting (early spring or fall) may not coincide favourably with construction schedule
- Areas that have been covered with seeded topsoil are susceptible to erosion until vegetation is established if RECP are not used.
 - Use of topsoil and mulch can reduce rain drop erosion potential during germination and until vegetation is established
 - Additional erosion control measures, such as RECP, may be required for steep slopes and channels
- Reseeding will be required in areas of limited plant growth
- Time to establish root structure may be unacceptable for some high risk areas; sodding should be considered for these areas

Construction *(Note: For guidance only. A site specific design is required from designer/engineer.)*

- The site to be seeded should be prepared prior to seeding
 - Surface should be graded to design grades and then topsoiled
 - Topsoil should be roughened, harrowed, or grooved
 - Seedbed should be 75 to 150 mm deep, with the top 75 mm consisting of topsoil free of large clods or stones
- Seed should be applied immediately after seedbed preparation using broadcast seed spreaders, cyclone (broadcast) spreaders, or seed drills to ensure uniformity of application
- Seedbed should be harrowed, raked, or chain-dragged to ensure proper seed-soil contact
- Fertilizer should then be applied after seeding

Construction Considerations

- Selection of proper vegetation seed mix depends on soil conditions, climate conditions, topography, land use, and site location
 - Selected seed mixes must be appropriate for site specific conditions
 - Some jurisdictions have developed recommended seed mixes for specific regions based on historic performance results
 - Qualified agronomists or agrologists should be consulted if a suitable seed mix is not identified
- Seeding rate for all mixes should be 25 kg/ha minimum
- Fall rye may be added at 5 kg/ha to provide early growth and protection from soil erosion
- Planting of seeds by hydraulic seeding and mulching techniques should be considered for slopes steeper than 3H:1V, or where application of seed, mulch, and fertilizer in one continuous operation is desirable
- Sod may be installed for faster results, however it is very costly but essential for high risk sensitive areas
- If mulch is placed as a germination medium for seeds, the mulch layer may be further protected with a biodegradable matting to prevent mulch from being washed or blown away

Inspection and Maintenance

- Inspect seeded areas one year after initial seeding or after significant storm events to evaluate germination and seedling density results
- Freshly seeded areas should be inspected frequently to ensure growth is progressing
- Additional erosion control measures should be considered for areas damaged by runoff
- Reseedings may be required within 1 to 5 year intervals after initial seeding
- Small bare spots may need to be reseeded several times at subsequent years after initial application; larger areas may need to be completely retreated
- Cutting or mowing grasses will encourage the establishment and spread of the grass

Similar Measures

- Hydraulic seeding and mulching
- Sodding

Design Considerations

- Seed application rate of 25 kg/ha may be used
- If fall rye is to be added, it should have an application rate of 5 kg/ha
- When using a seed drill or billion seeder, grasses and legumes should not be planted deeper than 1 cm
- Bacterial inoculants must be used when seeding with legumes
- Fertilizer, in lieu of a soil test, should be applied as per the supplier's recommendations or:
 - it should be applied at a rate of 50 to 75 kg of nitrogen/ha, depending upon site conditions
 - fertilizer use should be carefully controlled as this may increase nutrient loading to receiving streams if runoff is not controlled properly
- Seeding should occur during periods when germination can be successful and plants have sufficient time to become established before the end of the growing season
- Seeding should not occur after the 50% frost probability date for the site
- Mulch is required when broadcast seeding or if seeding is carried out after the date specified in which fall seeding should not be carried out
- For specific needs of local growth environment, specific design and advice from local seed supplier or professional agrologist may be required.

Description and Purpose

- Application of organic material or other normally biodegradable substances as a protection layer to the soil surface to:
 - minimize raindrop/runoff erosion and conserve a desirable soil moisture property for plant growth; and
 - promote seed germination and plant growth
- Mulches conserve soil moisture, reduce runoff velocities and surface erosion, control weeds, help establish plant cover, and protect seeds from predators, raindrop impact, and wind/water erosion

Applications

- Can be used to provide temporary and permanent erosion control
- Can be used as an organic cover or growth medium for seeds where topsoil is not readily available
- May be used with or without seeding in areas that are rough graded or final graded
- May be applied in conjunction with seeding to promote plant growth
- May comprise organic mulches (such as straw, wood fibres, peat moss, wood chips, pine needles, compost) or chemical mulches (such as vinyl compounds, asphalt, rubber, or other water-mixed substances)
- Chemical mulches may be used to bind other mulches in a hydroseeding/hydromulching application

Advantages

- Relatively cheap method of promoting plant growth and slope protection

Limitations

- Application of mulch may be difficult on steep slopes
- May require spray-on method to apply mulch with tackifier to provide adhesion to steep slopes

Installation

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil and seed, if required, subject to topsoil availability
- Apply mulch as per supplier's recommendations
- Certain mulches may require additional anchoring to minimize loss of mulch due to wind or water erosion

Construction Considerations *(Note: For guidance only. A site specific design is required from designer/engineer.)*

- Install mulches as per manufacturer or supplier recommendations
- Organic Mulches
 - Straw
 - Refers to stalks or stems of small grain (primarily wheat) after drying and threshing
 - Straw should be free of weeds
 - Loose straw is very susceptible to movement by blowing wind and water runoff and should be anchored either with chemical tackifier or some form of netting
 - When properly secured to surface, straw is highly suitable for promoting good grass cover quickly, however, it may be a fire hazard in dry conditions
 - Raw Wood Fibre
 - Mixture of cellulose fibres a minimum of 4 mm in length extracted from wood
 - Wood fibres usually require a soil binder and should not be used as erosion control during periods of hot dry weather in the summer or for late fall seeding unless it is used in conjunction with another suitable mulch as it is prone to removal by blowing wind or water runoff
 - Wood fibre is primarily used in hydroseeding-hydromulching operations where it is applied as part of a slurry and when used in conjunction with a tackifier, it is well suited for tacking straw mulch on steep slopes
 - Peat Moss

- Comprises partly decomposed mosses and organic matter under conditions of excessive moisture
- Usually available in dried and compressed bundles
- Should be free of coarse material
- Useful soil conditioner to improve organic content of soil promoting plant growth
- Highly susceptible to removal by blowing wind and water runoff if dry and spread on top of soil
- Wood Chips
 - By-products of timber processing comprised of small, thin pieces of wood
 - Decompose slowly
 - Suitable for placing around individual plants (shrubs and trees) and for areas that will not be closely mowed
 - Highly resistant to removal by blowing wind and water runoff
- Bark Chips (Shredded Bark)
 - By-products of timber processing comprised of small, thin pieces of tree bark
 - Suitable for areas that will not be closely mowed
 - Have good moisture retention properties and are resistant to removal by blowing wind and water runoff
- Pine Needles
 - Comprise needles from coniferous trees (pine, spruce)
 - Needles should be air dried and free of coarse material
 - Decompose slowly
 - Suitable for use with plants that require acidic soils
 - Resistant to removal by blowing wind and water runoff
- Compost (Straw Manure)
 - Comprised of organic residues and straw that have undergone biological decomposition until stable
 - Should be well shredded, free from coarse material, and not wet
 - Has good moisture retention properties and is suitable as a soil conditioner promoting plant growth
 - Relatively resistant to removal by blowing wind and water runoff if not dried out completely
- Chemical Mulches
 - Comprised of acrylic co-polymers, vinyl compounds, asphalt, rubber, or other substances mixed with water
 - Usually used in hydroseeding-hydromulching applications
 - Should be applied in accordance with supplier's recommendations

Inspection and Maintenance

- Inspect mulched areas at least once per year or after significant storm events (1:2year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rilling should be regraded if necessary and recovered with mulch immediately
- Additional stormwater control measures should be considered for areas of severe rilling erosion damaged by runoff
- Small bare spots may need to be reseeding and recovered with mulch

Similar Measures

- Topsoiling
- Hydraulic seeding and mulching (hydroseeding, hydromulching)
- Rolled erosion control products (RECP)

Description and Purpose

- The spraying-on of a slurry to a slope or channel surface to provide a layer of seed and growth bedding medium
- The slurry consists of seed, fertilizer, mulch, tackifiers, and water which are mixed together in a tank
- Enables quick re-vegetation of very steep or rocky/gravelly slopes where revegetation by any other method would be very difficult or unsafe; frequent reseeding and special mix design may be required
- When sprayed on the soil, the slurry forms a continuous blanket with seeds and protects the soil from wind and water erosion and raindrop impact by aggregating (or adhering) them in place
- The slurry conserves moisture, reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation/drying of soil

Applications

- Can be used to provide temporary and permanent erosion control prior to establishment of vegetation
- Slurry is held in suspension through consistent agitation and is sprayed onto disturbed areas using high pressure pumps
- Can be used for spray-on seeding covering large areas efficiently after placement of topsoil
- May be used to provide soil stabilization for seeding disturbed soil areas
- Can also be used with higher efficiency and large area coverage with Advantages over conventional methods (broadcast seeders, drill seeders)
- Can be used in areas where little topsoil is available

Advantages

- Relatively cheap and efficient spraying method of seeding and promoting plant growth as well as erosion protection
- Allows spray-on re-vegetation of steep slopes where conventional re-vegetation methods are very difficult
- Minimizes effort required to re-vegetate disturbed areas as hydroseeding/hydromulching usually only requires one spray-on operation in comparison with planting and farrow method
- Relatively efficient operation with high coverage rates
- Provides dust control and protection from wind erosion

Limitations

- Site must be accessible to hydroseeding/hydromulching equipment
 - Usually mounted on trucks
 - Maximum hose range of approximately 150 m
- May require subsequent spraying to reseed bare spots or areas with low growth

Construction *(Note: For guidance only. A site specific design is required from designer/engineer.)*

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil if available
- Spray on hydroseed-hydromulch as per supplier's recommendations

Construction Considerations

- Seed
 - Selected seed mixes must be appropriate for site specific conditions
 - Some jurisdictions have developed recommended seed mixes for specific regions based on historic performance results

- Qualified agronomists or agrologists should be consulted if a suitable seed mix is not identified
- Hydraulic Mulches
 - Cellulose
 - Comprised of recycled paper from newspapers, magazines, or other paper sources
 - Rapid method for applying seed, fertilizer, mulch, and water in almost any disturbed areas
 - Usually installed without tackifier in slurry
 - Short fibre lengths and lack of tackifier limits erosion control effectiveness and does little to moderate moisture content and temperature within the soil
 - Residual inks within the recycled paper may leach into soil, which may present a problem in environmentally sensitive areas
 - Longevity significantly shorter than for wood fibre mulches or bonded fibre matrices (BFM)
 - Cheaper than wood fibre mulches and BFM
 - Wood Fibre
 - Comprised of whole wood chips
 - Industry standard, provides quick and uniform method and medium for revegetating large areas quickly and economically
 - Longer fibre lengths than for cellulose mulches
 - Longer lasting and has better wet-dry characteristics than cellulose mulches
 - Provides limited erosion control even when sprayed on with tackifiers
 - Provides limited moderation of soil moisture content and temperature when applied at higher rates
 - Cheaper, but less effective than, BFM
 - More expensive, and more effective than, cellulose mulches
 - Bonded Fibre Matrices (BFM)
 - Slurry comprised of either cellulose mulch, wood fibre mulch, or a combination of the two
 - Mulches are bound together using chemical bond, mechanical bond, or a combination of the two
 - All fibres and binding agents are premixed by the manufacturer, ensuring uniformity and consistency throughout the application
 - Well suited for sites with existing desirable vegetation and where worker safety and minimal ground disturbance are desired
 - Degree of protection is similar to that obtained from rolled erosion control products (RECP)
 - Quicker installation than for RECP
 - Chemically bonded BFM may require a 'set-up' or curing/drying period
 - Application must be limited to periods where there is no threat of rain during curing period
 - Mechanically bonded BFM have no curing time and are effective immediately after application
 - Application on dry soils is not recommended
 - More expensive, and more effective, than cellulose and wood fibre mulches
- Tackifiers
 - May include vinyl compounds, asphalt, rubber, or other water-mixed substances

Inspection and Maintenance

- Inspect hydroseeded-hydromulched areas at least once per year after initial
- application or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by runoff may need to be repaired and protected
- Small bare spots may need to be reseeded

Similar Measures

- Seeding
- Mulching
- Rolled erosion control products (RECP)

Topsoiling *Revegetation*

BMP 21

Description and Purpose

- The covering of exposed mineral soils with soils of high organic content to minimize raindrop erosion potential
- Provides a medium for vegetation to grow

Applications

- Permanent measure
- May be used to provide a bedding medium for seed germination and a cover to exposed soil that is not suitable to promote vegetation growth
- May be used on slopes with a maximum gradient of 2H:1V
- Normally topsoil is placed prior to seeding, mulching, hydroseeding-hydromulching, seeding and installing rolled erosion control products (RECP), or planting of trees/shrubs

Advantages

- Placing topsoil provides enriched organic medium for vegetation root structure to grow
- Topsoil organic content provides nutrients to promote plant growth
- Absorbs raindrop energy to reduce erosion

Limitations

- Not appropriate for slopes steeper than 2H:1V
- Placing and grading topsoil can be time consuming and expensive
- Dry topsoil may be removed by blowing wind
- Topsoil may not be readily available in some areas

Construction *(Note: For guidance only. A site specific design is required from designer/engineer.)*

- Prepare ground surface to final grade by removing large rocks or other deleterious materials
- Apply topsoil with dozer or light track equipment to design thickness
- Track walk upslope or downslope (do not overcompact topsoil by heavy equipment; only track walk one pass) to provide a contour of roughness of topsoil to further minimize erosion

Construction Considerations

- Topsoil should be free of weeds which may inhibit re-vegetation of desirable plants
- Subgrade should be roughened by track walking up/down the slope prior to topsoiling to promote adhering of topsoil to subgrade (surface roughening of subgrade is especially required if topsoiling is not scheduled immediately after completion of the grade)
- Topsoil should be moistened regularly during periods of hot dry weather to minimize wind erosion
- Hydroseeding-hydromulching topsoil will minimize wind erosion of topsoil

Inspection and Maintenance

- Inspect topsoiled areas at least once per month after initial application or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rilling should be regraded and re-topsoiled immediately

Similar Measures

- Hydroseeding-hydromulching
- Mulching
- Rolled erosion control products (RECP)

•
Description and Purpose

- Consists of installing woody plantings (trees and shrubs) to develop a root matrix within the soil, increasing subsurface soil strength and stabilizing slopes with deeper root systems than grasses
- Reduces erosion potential of slopes and channel banks

Applications

- Temporary or permanent measure
- May be used on slopes stable enough to support vegetation; however, there is a low success rate for steep slopes and channel banks with gradients greater than 1H:1V
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as bio-engineering stabilization of historical shallow slope instability soil movements on eroded slopes and gullies
- May be used along channels to provide higher channel roughness to reduce flow velocity and in sedimentation ponds to provide higher sedimentation duration of runoff impoundment

Advantages

- Promotes development of organic mat
- Dense leaves and large diameter plant stalks increases channel roughness and reduces flow velocities in channel thus decreasing erosion potential
- Traps sediment laden runoff and stabilizes soil
- Aesthetically pleasing once developed
- Grows stronger with time as root structure develops
- Usually has deeper root penetration than grass with greater depth of stabilization
- Manual planting may be attempted on steep slopes that are sensitive to machinery disturbance or represent an area of high erosion potential

Limitations

- Can be labour intensive to install
- Some level of uncertainty as success of plant growth is dependent on various unknown site parameters (i.e. moisture, soil, terrain, weather, seeding conditions, etc.)
- Revegetated areas are susceptible to erosion until vegetation develops; and should be used in conjunction with hydroseeding and/or mulching
- Plants may be damaged by wildlife
- Potential for low success rate
- Few precedents as this measure is generally not used on AT construction projects

Construction *(Note: For guidance only. A site specific design is required from designer/engineer)*

• **Live Staking**

- Used on cut or fill slopes or in ditches/channels
- Comprised of willow or poplar stakes inserted into the ground; other indigenous plants may be acceptable
- Individual dormant willow or poplar stakes should be cut to a minimum length of 0.5 m using pruning shears
- Cuts should be made at a 45° angle a minimum of 0.05 m (5 cm) below a leaf bud
- All side shoots should be trimmed to within 0.05 m of the main stem
- Install live stakes in a 1 m by 1 m grid
- Make a pilot hole a minimum of 0.3 m in depth to insert live stake into
- Use iron bar, broom handle or other tool to make pilot hole
- Insert live stake into pilot hole and lightly tamp soil around live stake
 - A minimum of two leaf buds should remain above grade

- **Brush Layers**

- Comprised of layers of live branches placed on terraces on slopes
- Excavate terraces perpendicular to direction of slope spaced approximately 1 m apart across entire width of slope to be protected
- Slope terraces at an angle of 10° upwards from the back of the terrace towards the slope face
- Place layers of branches on the terrace
- Use Individual dormant willow or poplar branches a minimum length of 1 m and a minimum diameter of 0.025 m (25 mm)
- Place brush layer approximately 0.1 to 0.2 m thick
- Ensure a minimum length of 0.1 to 0.2 m of the branch is protruding from face of slope
- Backfill and tamp soil over brush layer

Construction Considerations

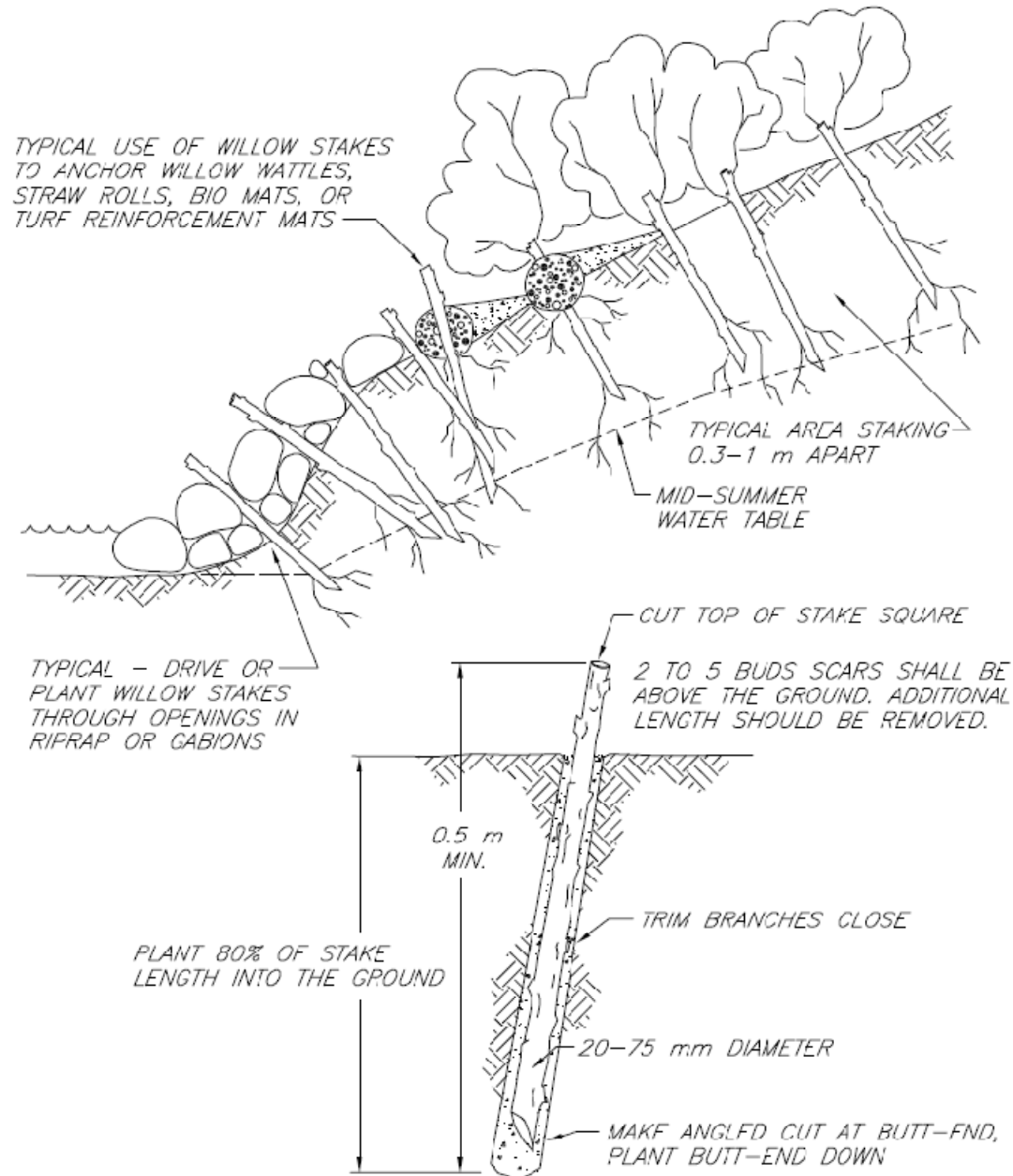
- Successful installation requires the use of freshly cut branches or stakes
 - Storage time of cut branches/stakes on-site prior to installation should be kept to as short a time period as possible
- Successful growth dependant on soil moisture and rainfall conditions
- Consultation with agrologist, greenhouse growers, local expertise can be beneficial in selecting and procuring appropriate species for planting

Inspection and Maintenance

- Inspect planted areas at least twice per year or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
 - Areas damaged by washout or erosion rilling should be replanted immediately
- Additional stormwater control measures should be considered for severe rilling areas damaged by runoff
- Watering plants is required for first one to two months after planting

Similar Measures

- Seeding
- Mulching
- Hydroseeding-hydromulching
- Rolled erosion control products (RECP)



NOTES:

1. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON.
2. USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD.
3. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS.
4. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
5. TAMP THE SOIL AROUND THE STAKE.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

FILE: LVSTK

NOT TO SCALE

LIVE STAKING

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan		Revision		Page
			#	Date	
	Report No. 504832-0000-4EPA-0005		PB	2011- 06-24	67

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	68

Appendix F

ENVIRONMENTAL BEST MANAGEMENT PRACTICES (EXAMPLES FROM CONSTRUCTION) – EROSION AND SEDIMENT CONTROL

Environmental Best Management Practices (Examples from Construction)

EROSION AND SEDIMENT CONTROL

Environmental Best Management Practices (Examples from Construction)

Crown Ditches: Erosion and Sediment Control



Cut Slopes Stability

Environmental Best Management Practices (Examples from Construction)

Ditches to collect run off



Energy Dissipaters in ditch



Energy Dissipaters in ditch

Environmental Best Management Practices (Examples from Construction)



**Mechanical and
Biological
Stabilization**

**Cut and Fill
Stabilization**



Environmental Best Management Practices (Examples from Construction)



Cut and Fill Stabilization

Mechanical and Biological Stabilization



Environmental Best Management Practices (Examples from Construction)

Silt Fence to control/prevent sediment from entering waterbodies



Environmental Best Management Practices (Examples from Construction)

Sediment ponds



TSS control

Environmental Best Management Practices (Examples from Construction)

Toe ditches



Collect water and sediments at the toe of fill slope

Environmental Best Management Practices (Examples from Construction)

Diversion channel



Channel banks protected

Environmental Best Management Practices (Examples from Construction)



Lined Diversion Channel / Ditch



Environmental Best Management Practices (Examples from Construction)



**Combination of
Geotextile/Sand Bags and
Natural brush bales**

Sediment Control



Environmental Best Management Practices (Examples from Construction)

Water filtration

Local Brush Bales



Rocks and Rip Rap



Silt fence

Environmental Best Management Practices (Examples from Construction)

Water filtration



Environmental Best Management Practices (Examples from Construction)

Slope Stabilization



**Seeding on Erosion
Control Blanket**



Hydroseeding

Environmental Best Management Practices (Examples from Construction)

Slope Stabilization



Installation of ECB



**Installation of Fascines and
planting of Vetiver**

Environmental Best Management Practices (Examples from Construction)



Using Local Materials

Slope Stabilization



Environmental Best Management Practices (Examples from Construction)

Slope Stabilization



Fascines and Vetiver



ECB, Fascines and Vetiver

Environmental Best Management Practices (Examples from Construction)

Slope Stabilization



ECB



Terraces on slopes using Rocks

Environmental Best Management Practices (Examples from Construction)

Slope compaction



Environmental Best Management Practices (Examples from Construction)

Water crossings



Rip Rap Upstream and Downstream

Environmental Best Management Practices (Examples from Construction)

Water crossings



Banks Stabilization: Gabions used at water crossing



Ford Crossing

Environmental Best Management Practices (Examples from Construction)

Water exits along RoW



Rocks as energy dissipater along the chute

Environmental Best Management Practices (Examples from Construction)

River bank stabilization – rip rap



Environmental Best Management Practices (Examples from Construction)

River bank stabilization rip rap and silt fence



Environmental Best Management Practices (Examples from Construction)

Slope Stabilization and Revegetation



Environmental Best Management Practices (Examples from Construction)

Manual Seeding



Topsoil spreading



Scarified topsoil

Environmental Best Management Practices (Examples from Construction)

Manual Seeding



Pre-measuring area



**Mixing of lime, fertilizer,
topsoil and seeds**

Environmental Best Management Practices (Examples from Construction)

Manual Seeding



Hand seeding



Growth after 3 months

Environmental Best Management Practices (Examples from Construction)

Hydroseeding



Scarification prior to seeding



Spraying

Environmental Best Management Practices (Examples from Construction)



Revegetation

ROW Rehabilitation



Environmental Best Management Practices (Examples from Construction)

Hydroseeding



Spraying with binder mulch



Spraying without binder

Environmental Best Management Practices (Examples from Construction)

Hydroseeding



Directly after hydroseeding



One month after hydroseeding

Environmental Best Management Practices (Examples from Construction)

Cut and Fill Slope Hydroseeding



Environmental Best Management Practices (Examples from Construction)

Planting



**Planting of native species in
ecologically sensitive area**



**Planting of crops for villagers
affected by Pipeline**

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	69

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	70

Appendix G

GERENCIA AMBIENTAL

MPSA'S CONTROL DE LA EROSION (PRO-100215), CRITERIOS DE CIERRE Y REHABILITACION (PRO-100228) AND REVEGETACION (PRO-100216) TECHNICAL DOCUMENT

	GERENCIA AMBIENTAL MPSA	PRO-100215-Control de la Erosión-MA
CONTROL DE LA EROSION		
Elaboró: Carlos Sánchez	Revisó: Gina Román	Aprobó: Gina Román

1. OBJETIVO

Brindar los lineamientos necesarios para la realización de los trabajos de control de la erosión de acuerdo a los requerimientos ambientales del estado panameño de MPSA, con la finalidad de proteger el suelo, reducir la tasa de erosión y propiciar la adecuada revegetación en las zonas que han sido intervenidas por MPSA.

2. ALCANCE

Este procedimiento aplica a todos los departamentos de MPSA y contratistas involucrados en las actividades de control de la erosión.

3. RESPONSABILIDADES

ACCIONES A REALIZAR	GO	GC	GM	GS	SB	SF	T	CO
1. Cumplir con los lineamientos incluidos en el presente procedimiento.			R		R	R	R	R
2. Planificar las compras de los insumos para control de erosión.		P	P		P	R		
3. Planificar oportunamente los trabajos de control de erosión para las áreas en procesos de cierre.			P		R	R		
4. Asesorar y supervisar la ejecución de los trabajos de control de erosión.			P		P	R		
5. Asesorar y supervisar la seguridad de los trabajadores.				P	P	R		
6. Coordinar con el Departamento de Medio Ambiente la inclusión de nuevos trabajos de control de erosión	R		P		P	P		

GO: Gerente de operaciones
GC: Gerente de contratos
GM: Gerente de Medio Ambiente
GS: Gerente de Salud y Seguridad Ocupacional
SB: Superintendente de Biodiversidad y Forestal.

SF: Supervisor Forestal
T: Trabajador de la empresa
CO: Contratista de la empresa
R: Responsable de la actividad
P: Participa en la actividad

4. DEFINICIONES

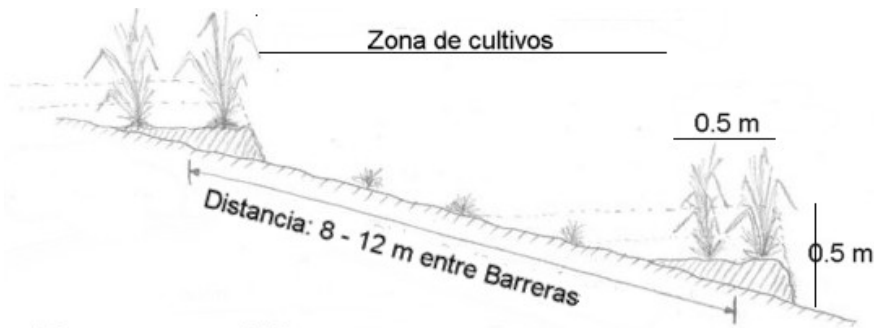
4.1. Control de la erosión:
Es el manejo que limita las tasas de erosión de un determinado suelo, las prácticas de control de la erosión son variadas y pueden ser clasificadas como prácticas mecánico estructurales (bancales, terrazas o gradadas), prácticas de protección de cobertura de suelo (mantas, mulching, biomantas).

5. PROCEDIMIENTO

5.1 Métodos de control de la erosión aplicables al proyecto.

Minera Panamá Gerencia Medio Ambiente	GERENCIA AMBIENTAL MPSA	PRO-100215-Control de la Erosión-MA
CONTROL DE LA EROSION		
Elaboró: Carlos Sánchez	Revisó: Gina Román	Aprobó: Gina Román

- Barreras de vegetación:** Sin hileras o líneas de plantas, arbustos y árboles de porte medio sembrados en forma densa, a distancias que oscilan entre 20 cm y 3 m, dependiendo de las especies, clima, suelo y pendiente de las laderas (Fig. 1 y 2); se trata de una práctica de conservación de suelos ampliamente conocida y utilizada, la cual puede ser empleada como una técnica de recuperación de suelos, mediante la introducción de algunas variantes que permitan a las plantas que se introduzcan, prosperar en un medio tan desfavorable.



Barreras Vivas

Figura 1. Barreras vivas. Diseño.



Figura 2. Barreras Vivas con especies arbustivas y arbóreas.

- Mantos orgánicos o biomantas:** Los mantos orgánicos pueden ser de yute, fique, fibra de coco, fibra de madera, excelsior. Para los mantos orgánicos (Figura 2), generalmente se colocan las semillas con suelo orgánico o con lodo fertilizado y se cubren con la biomanta (Figura 2). En ocasiones solo se coloca la semilla y la manta, dependiendo del tipo de suelo. Es muy importante tener presente la acidez y fertilidad del suelo, antes de colocar la biomanta, para así tener mejores resultados.

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Si el tipo de suelo es el adecuado, en dos o tres meses se puede tener la cobertura vegetal.



Figura 2. Mantos orgánicos o biomantas.

Esta técnica puede ser utilizada en pendientes con gran altura (Figura 3 y 4), sin embargo cuando el talud está totalmente vertical, esta técnica no es muy efectiva.

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Figura 3. Mantos orgánicos en taludes con pendientes pronunciadas



Figura 4.- Mantos orgánicos en taludes con pendientes pronunciadas.

Es muy importante tener presente, que si, las biomantas no se fijan adecuadamente al terreno la técnica no es muy efectiva. Las biomantas pueden fijarse o ser anclados, con pasto vetiver (*Vetiveria zizanioides*) (Figura 5). También se pueden utilizar grapas de 6 pulgadas y ser colocadas en formación 2 – 1. Normalmente se usan de 2.4 a 2,8 grapas por m2.

Dependiendo del tipo de biomanta, se requiere romper la misma (Figura 6), para permitir el desarrollo de la vegetación (cuando el material es muy tupido, por ejemplo el fique). Los estolones de pasto, también pueden ser sembrados sobre la biomanta (Figura 5).

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Figura 5. Biomantas revegetadas.



Figura 6. Biomantas revegetadas

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CONTROL DE LA EROSION		
Elaboró: Carlos Sánchez	Revisó: Gina Román	Aprobó: Gina Román

- **Mateo en taludes verticales:** Esta técnica (Figura 6) consiste en hacer pequeños huecos en los cuales se siembran matas de pasto o de hierba.



Figura 5 Técnica del mateo

- **Gradas o escalones:** Esta técnica de gradas, disipa la energía del agua de escorrentía. Los escalones pueden ser continuos o en tres bolillos (Figuras 7). Generalmente, la vegetación se desarrolla mejor en el sitio del escalón. La Figura 8 muestra el diseño general para este tipo de técnica.

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CONTROL DE LA EROSION		
Elaboró: Carlos Sánchez	Revisó: Gina Román	Aprobó: Gina Román



Figura 7. Gradas o escalones.

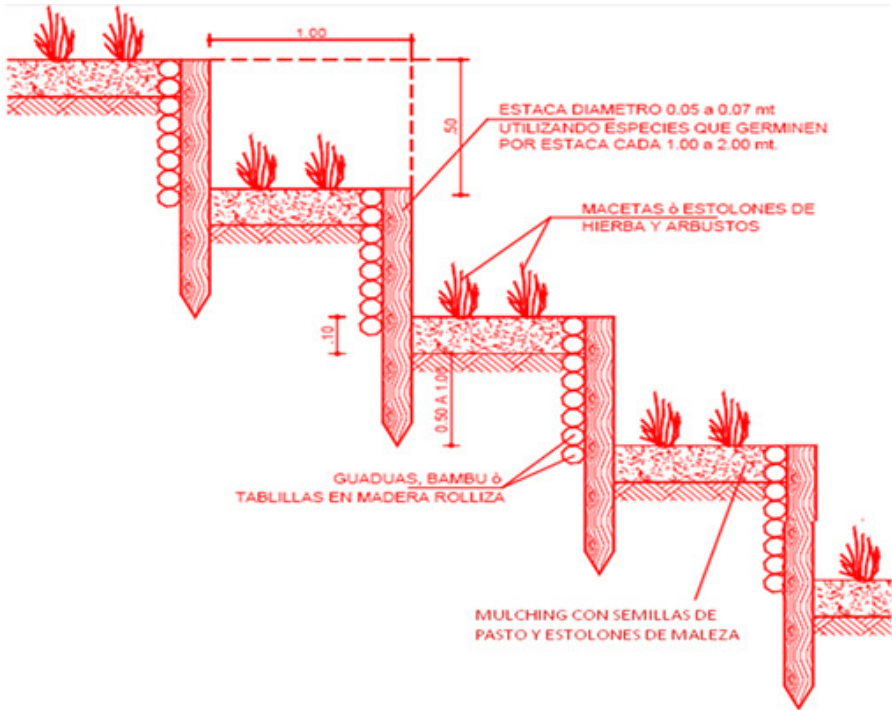


Figura 8. Gradas o escalones. Diagrama.

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CONTROL DE LA EROSION		
Elaboró: Carlos Sánchez	Revisó: Gina Román	Aprobó: Gina Román

- **Cespedones de pasto:** Esta técnica (Figura 9) no se recomienda para pendientes muy fuertes.



Figura 9. Cespedones de pasto.

5.2 Requerimiento de personal y mano de obra:

Las prácticas de control de la erosión descritas pueden ser realizadas con una cuadrilla de trabajo de por lo menos 4 personas, y una cuadrilla de motosierrista y su respectivo ayudante.

Se estima que un motosierrista y su ayudante pueden habilitar los troncos disponibles de las labores de apertura de la plataforma que se usarán para el control de la erosión en las plataformas de exploración en un máximo de 0.5 días por plataforma.

Se estima que una brigada de control de la erosión puede realizar las labores de conformación en un máximo de 0.5 días por plataforma de exploración (en zonas de acceso terrestre) y de 0.2 días (en zonas de acceso aéreo). La brigada está compuesta por 4 operarios.

6.0 REFERENCIAS

- PRO-100216-Revegetación-MA
- PRO-100228-Criterios de Cierre y Rehabilitación-MA

	GERENCIA AMBIENTAL MPSA	PRO-100216-Revegetación-MA
REVEGETACION		
Elaboró: Carlos Sánchez	Revisó: Gina Roman	Aprobó: Gina Román

1. OBJETIVO Brindar los lineamientos necesarios para la realización de los trabajos de revegetación, de acuerdo a los requerimientos ambientales del estado panameño y de los estándares de MPSA, con la finalidad de proteger el suelo, reducir la tasa de erosión y disminuir la generación de sólidos totales en suspensión, en las zonas que han sido intervenidas por MPSA.

2. ALCANCE
Este procedimiento aplica para todas las áreas del proyecto, donde sea necesaria la revegetación, lo cual incluye plataformas y taludes de carreteras, entre otros.

3. DEFINICIONES

3.1. Siembra Manual
Es un método de revegetación que consiste en la siembra manual de pastos nativos y/o plantaciones forestales. La finalidad de este método es conseguir una cobertura vegetal rápida que ayude a controlar la erosión del suelo.

3.2. Hidrosiembra
Es una técnica de revegetación, que usa una mezcla homogénea de semillas, mulch (sustrato inorgánico), fijadores, fertilizantes y aditivos dispuestos sobre un terreno. Para su aplicación se utiliza una máquina hidrosembradora y es recomendable su aplicación en taludes cuya pendiente no permitiría la siembra manual.

4. RESPONSABILIDADES

- Es responsabilidad del Gerente de Medio Ambiente supervisar los trabajos de revegetación para las áreas en procesos de construcción y cierre, así como realizar las coordinaciones con los responsables y áreas involucrados.
- Es responsabilidad del personal de MPSA y contratistas involucrados en los trabajos de revegetación, cumplir con los lineamientos incluidos en el presente procedimiento.
- Es responsabilidad de los distintos departamentos de MPSA y de los contratistas, coordinar con el Departamento de Medio Ambiente la programación y/o la inclusión de nuevos trabajos de revegetación de manera oportuna, para poder organizar las labores de supervisión asociadas.

5. PROCEDIMIENTO

5.1 REVEGETACIÓN.- Minera Panama tiene como premisa la utilización de especies nativas adaptadas a las condiciones de la zona de ejecución del proyecto, en todas las situaciones en donde sea factible, como la primera opción para el desarrollo de cobertura vegetal en las zonas intervenidas.

Esta decisión además es compatible con el enfoque de sostenibilidad e incorporación de conocimiento y prácticas locales en el proyecto. El uso de fertilizantes y agroquímicos estará limitado y solo se utilizará en la etapa de establecimiento de las zonas a revegetar.

5.1.1 Siembra Manual
Para este tipo de siembra se emplean cuadrillas de aproximadamente 4 personas cada una, obteniendo un rendimiento de 02 plataformas diarias de revegetación por cuadrilla, zonas aperturas mediante acceso terrestre y rendimiento de 05 plataformas en zonas aperturas vía aérea. Este rendimiento es posible solo si todas las prácticas de control de la erosión y conformación de las plataformas han sido culminadas previamente.

Además para realizar este tipo de siembra se deben ejecutar las siguientes actividades como prerrequisito:

5.1.1.1 Mejoramiento en la fertilidad del Suelo
• Incorporación de fertilizantes.

	GERENCIA AMBIENTAL MPSA	PRO-100216-Revegetación-MA
REVEGETACION		
Elaboró: Carlos Sánchez	Revisó: Gina Roman	Aprobó: Gina Román

Para compensar la deficiencia de nutrientes en el suelo se incorporan, dependiendo de la condiciones de fertilidad del suelo y de las exigencias de la especie a instalar, fertilizantes químicos y orgánicos tales como:

5.1.1.2 **Siembra de pastos**

• **Incorporación de semillas al voleo**

Luego de preparar el suelo se procede con la siembra de pastos, para este tipo de siembra se utilizan diferentes variedades de semillas nativas, utilizando las siguientes densidades de siembra.

Especie a revegetar	Ib/ha
“ratana”	70
“braquiara decumbes”	70

5.1.1.3 **Tapado de semillas**

Utilizando rastrillos tridentes se realiza el tapado de las semillas sembradas con la finalidad de favorecer su germinación cuando han sido sembradas en suelo desnudo, en caso las semillas se esparzan sobre biomantas la práctica recomendable es esparcir las semillas antes de la colocación de las biomantas.

5.1.2 Hidrosiembra En MPSA se utiliza este método para taludes cuyas pendientes son altamente pronunciadas (<2H:1V), no haciendo posible la siembra manual o donde la práctica de colocación de biomantas no resulte viable.

Para realizar este método de siembra se llevan a cabo los siguientes pasos:

5.1.2.1 **Preparación y Mezcla**

Consiste en abastecer al equipo de siembra de todos los insumos requeridos: semillas, fertilizantes, “mulch” y fijadores. Luego se realiza la mezcla o batido uniforme de todos los insumos incorporados. Los insumos que se utilizaran deberán considerar las siguientes condiciones para la formulación optima del “mulch”, fertilidad y especie a sembrar:

- Tipo de suelo
- Fertilidad de suelo
- Intensidad de precipitación horaria
- Pendiente de aplicación
- Selección de semilla nativa o exótica no invasiva adaptada a condición local

5.1.2.2 **Aplicación y Siembra**

Haciendo uso del equipo, se dispara la mezcla en los taludes y/o zonas a revegetar. Para este técnica se requiere el uso de una cantidad mayor de semillas que las usadas en la siembra manual (50% más), esto debido a que gran cantidad de semillas quedan a la intemperie y por consiguiente se tiene un mayor porcentaje de pérdida.

6.0 **REFERENCIAS**

- Procedimiento PRO-100228 “Criterios de Cierre y Rehabilitación”
- Procedimiento PRO-1002215 “Control de la Erosión”

	GERENCIA AMBIENTAL MPSA	PRO-100228-Criterios de Cierre y Rehabilitación-MA
Criterios de Cierre y Rehabilitación		
Elaboró: Carlos Sánchez	Revisó: Gina Roman	Aprobó: Gina Román

1. OBJETIVOS

- 1.1. Estandarizar y establecer los criterios a tomar en cuenta para la realización de todos los trabajos de rehabilitación realizados por MPSA.
- 1.2. Reducir o minimizar los impactos ambientales negativos, que por efecto del movimiento de tierras y erosión del suelo, pueden originar impactos en la calidad del agua de los ríos y quebradas, y en la conservación de la biodiversidad.
- 1.3. Cumplir con las exigencias de la legislación panameña y compromisos asumidos por MPSA.

2. ALCANCE

Este procedimiento es aplicable a todas las áreas involucradas en los trabajos de cierre y rehabilitación del proyecto “Cobre Panama”

3. RESPONSABILIDADES

- Es responsabilidad del personal de MPSA y contratistas, aplicar los criterios y descritos en este procedimiento.
- El Gerente de operaciones de MPSA tiene la responsabilidad de asegurar la correcta aplicación del procedimiento.
- Es responsabilidad del área de Medio Ambiente de MPSA, revisar e inspeccionar las áreas de rehabilitación, durante y luego de la realización de las labores de cierre.

4. PROCEDIMIENTO

4.1 Finalidades

- Controlar la erosión del suelo, evitando la generación de sólidos totales en suspensión en los cuerpos de agua adyacentes.
- Propiciar un crecimiento rápido y adecuado de cobertura vegetal en la zona cerrada.
- Conformar taludes u otras áreas disturbadas, en forma tal que se garantice la estabilidad y durabilidad de la capa de suelo superficial y la vegetación establecida.

4.2 Planificación

- Los trabajos de Rehabilitación que se piensan desarrollar durante el año en curso, deberán ser planificados y programados, en lo posible, evitando los meses de menor precipitación en la zona.

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- Todos los trabajos de cierre deberán estar considerados dentro de un plan de manejo Ambiental.

4.3 Criterios generales

- Se debe evitar, la contaminación de las aguas del río o cuerpos de agua cercanos, por residuos líquidos y sólidos, entre ellos, aguas servidas, grasas, aceites y combustibles, residuos de cemento, concreto, materiales sobrantes y otros. Por lo que antes de realizar las labores de control de la erosión y revegetación se debe coleccionar cualquier residuo que haya en el área.
- Se deberá descartar con anterioridad a la rehabilitación, la presencia de material potencial generador de acidez (PAG).
- Todos los sondajes de exploración deben de ser sellados luego de culminadas las actividades perforación
- Inmediatamente después de la re-conformación del terreno, se deben colocar los elementos de control de erosión adecuados, ver referencia en el documento **PRO-100215- Control de la erosión-MA** con el objetivo de minimizar la erosión mientras se desarrolle la vegetación.
- Para controlar la erosión de los cortes y rellenos recién hechos y la sedimentación temporal en las vías de drenaje natural, se protegerán las superficies susceptibles con una cubierta protectora y los canales de drenaje con bermas o barreras; además se instalarán pozas de disipación para detener el sedimento.
- Todas las pozas de contención de lodos de perforación o de sedimentación de los mismos, deben de ser rellenadas con el propio material removido durante la construcción de la plataforma.
- Es importante instalar en la zona revegetada, un sistema de drenaje adecuado que garantice el flujo superficial constante en la zona.
- La forma más efectiva de controlar la erosión es revegetando, trasplantando o sembrando, con el objetivo de estabilizar el suelo y asegurar el crecimiento adecuado de la cobertura vegetal.
- Con el fin de asegurar una efectiva cobertura vegetal de crecimiento rápido, la siembra de semillas debe hacerse de manera conjunta con una primera y única fertilización asistida. La cual estará en función del tipo de especie que se utilizará y de la calidad del suelo a revegetar.

5.0 MONITOREO

- Con el objetivo de evaluar la efectividad de los métodos utilizados para controlar la erosión y restituir la cobertura vegetal, se realizará un monitoreo aleatorio de las zonas cerradas más representativas. La frecuencia de monitoreo será semestral y se

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monitorearán las siguientes variables:

- Porcentaje de Cobertura Vegetal.
 - Estabilidad física de las zonas cerradas.
 - pH y conductividad del agua de escorrentía de las zonas cerradas.
 - Colecta de macro-invertebrados en cobertura.
- Los informes se producirán semestralmente y serán distribuidos internamente.

6.0 REFERENCIAS

- Procedimiento PRO-1002215 “Control de la Erosión”
- Procedimiento PRO-1002216 “Revegetación”
- SECA-Environment performance standard 3 “Closure Planning”

  Joint Venture Panama Inc.	Erosion and Sediment Control Plan	Revision		Page
		#	Date	
	Report No. 504832-0000-4EPA-0005	PB	2011- 06-24	71

DOCUMENT END